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LAUNCH OF H. M. S. LATONA.

THE launch of the first cruiser embraced in the programme of the Naval Defense Act of 1889 took place at Barrow, in May last, from the yard of the Naval Construction and Armaments Company. The cruiser, which is one of the three being built and engined by this company for H. M. government, was named Latona.

She is one of the second class of cruisers, of which twenty-six are to be built.

The Latona is one of the new type of protected cruisers and is of the following dimensions, viz.: 300 ft. long, by 43 ft. beam, by 23 ft. 9 in. moulded depth, having a displacement of 3,400 tons on a mean draught of 16 ft. 6 in. Externally the vessel has a very smart appearance, having two funnels and two pole masts, with a light fore-and-aft rig. The hull throughout is built of steel, the stern, stern post, propeller brackets, rudder, etc., being of cast steel. The propelling machinery consists of two sets of triple expansion engines with cylinders 33½ in., 49 in., and 74 in. in diameter by 39 in. stroke, capable of developing over 9,000 indicated horse power with the boilers worked under moderate forced draught. They are of the light type adopted in modern war vessels, cast and wrought steel being largely introduced into their construction.

The steam is supplied by five boilers, having an aggregate of 16,000 square feet of heating surface. The arrangement for forced draught is that known as the closed stokehold system, each stokehold being fitted with two powerful fans worked by separate engines for the supply of air. A distinctive feature of this cruiser is a steel protective deck extending fore and aft, the forward part running down with a long sweep to the ram of the vessel, of which it forms part. The transverse section of this structure is in the form of a flat deck, the crown of which rises about 1 ft. above the water line at center of vessel, and slopes down toward the sides to a point about 4 ft. below the load line. On the sloping part the average thickness is 2 in., with a thickness of 1 in. on the crown. Under the protective deck are placed the engines and boilers, magazines, steering gear, and other vital parts of the ship.

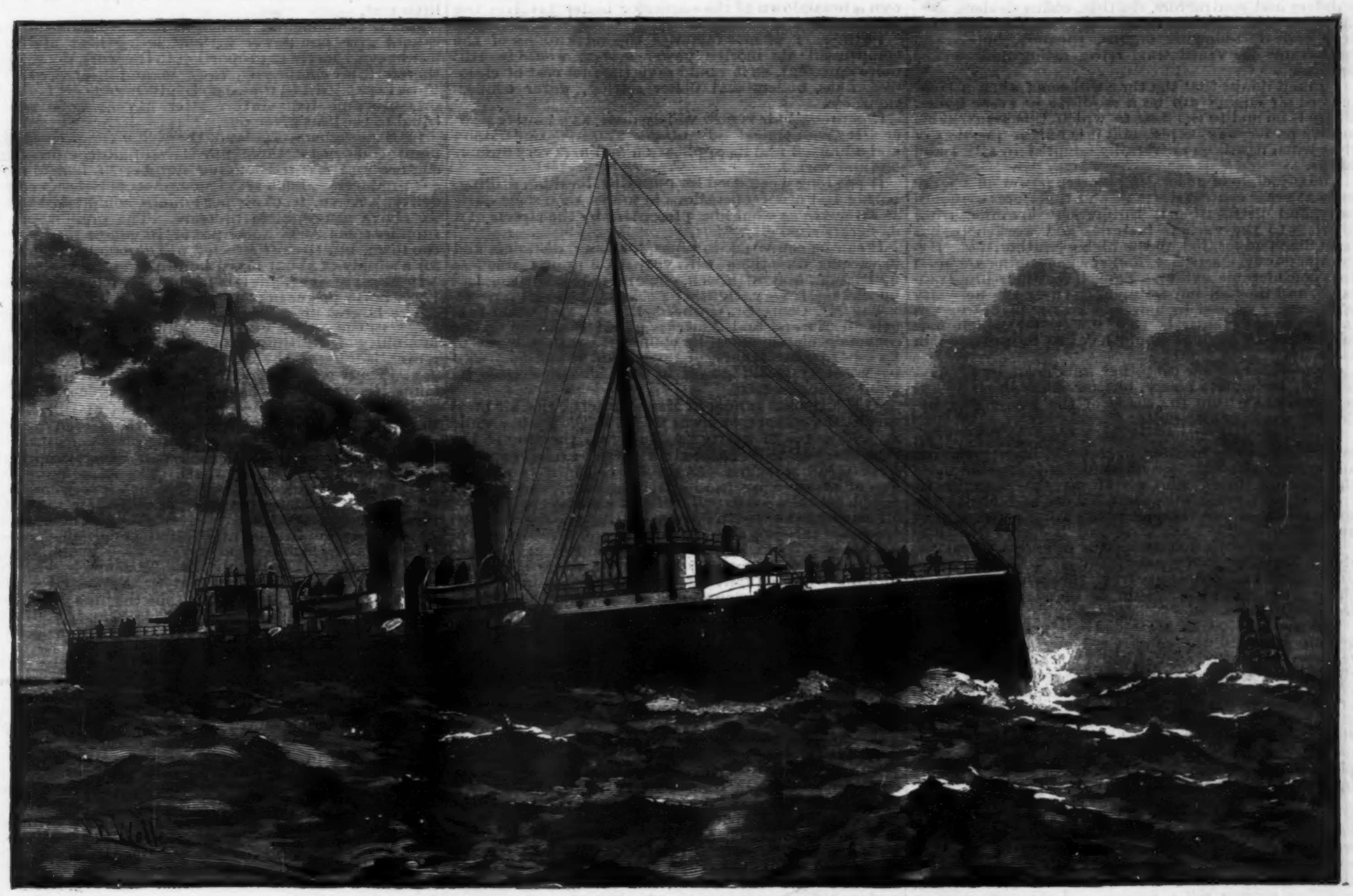
As, however, in the Latona vertical engines have been adopted instead of horizontal, as fitted in some of the former vessels of this type, the necessary protection for the parts of these projecting above the protective deck is obtained by fitting a belt of 5 in. steel armor, with 7 in. of teak backing, round the engine hatchway between the protective and upper decks. The subdivision into numerous watertight compartments has been, as usual in war ships, fully carried out in the Latona. For the full extent of the engine and boiler space a complete inner bottom is fitted, the continuity of which is carried forward and aft by the watertight flats forming the magazines and storerooms of the ship. Alongside the engines and boilers amidship coal bunkers are also fitted, formed by longitudinal bulkheads extending to the upper deck, thereby affording additional protection to the machinery. Moreover, numerous transverse bulkheads are fitted, the hull under the upper deck being thus divided into about 100 watertight compartments. The greater part of the hull admidships under the protective deck is occupied by the machinery, there being two separate engine and boiler rooms. Aft of the engine rooms are the magazines for the supply of the after guns, as well as the steering gear, both hand and steam, fitted in two separate compartments. Forward of the machinery spaces are the magazines for the forward guns, and the various store rooms required for the ship. Above the protective deck aft are the cabins for the ship's officers, the part amidships being occupied by the coal bunkers, artificers' workshops, wash places, etc., while the part forward is entirely devoted to the crew.

Under the poop are placed the cabins of the commander and principal officers, ward room, etc., the forecastle being taken up by the crew. The armament of the ship consists of two 6 in. breech-loading central pivot guns, one mounted on the poop and another on the forecastle. Six quick-firing 4·7 in. central pivot guns, three on each broadside, eight quick-firing 6 pounder guns, four on each broadside, besides a 3 pounder Hotchkiss, and four five-barrel Nordenfelt guns mounted at suitable stations along the sides of the vessel. One 9 pounder gun for boat and field purposes is also secured on deck. In addition to these there will be one aft and one on each broadside under front of poop. For controlling the ship in action, a conning tower of steel, 3 in. thick, is fitted on the after end of the forecastle inside, in which all the gear for manipulating the engines, steering gear, guns, etc., is placed.

As regards the pumping arrangements, an elaborate system of piping is fitted, extending to every compartment, while the fire service and sanitary arrangements are on the same elaborate scale. A complete installation of electric lighting is also fitted, including three powerful search lights.

The crew numbers 252 hands all told, for whose accommodation and comfort every care has been taken in the way of utilizing the living quarters to the best advantage.

For the above particulars and for our engravings of the bow and stern of the Latona we are indebted to *The Engineer*, and for our portrait of the ship under steam to *The Graphic*, London.



H. M. S. LATONA, PROTECTED CRUISER, BUILT OF STEEL.

TRANSMISSION OF POWER BY COMPRESSED AIR.

DR. H. S. WEUSTHOFF, of Baltimore, Md., is an earnest advocate for the introduction of the compressed air system for the above city, and has lately issued a pamphlet upon the subject, from which we make the following quotations:

The scheme for such a system in Baltimore is based upon the "Report on a Scheme for supplying Compressed Air Motive Power in the Town of Birmingham, England," in 1883, which has since been carried out on the plans originally laid down by the engineers.

The information concerning the Paris plant is taken from the exceedingly interesting experiments upon the transmission of power by compressed air in Paris, made by Alex. B. W. Kennedy, F. R. S., M. Inst. C. E., Emeritus Professor of Engineering and Mechanical Technology in University College, London, England.

Compressed air has become indispensable in mining and tunneling work. It not only supplies motive power to the drills and mine locomotives, which have to a great extent supplanted mules, but supplies also the fresh air so necessary in carrying on such work. In the Mt. Cenis tunnel compressed air was used to operate the drills, the compression being effected by taking advantage of the natural heads of water, which were made to act directly in compressing the air; the pressure due to a column of water 160 feet high being made to act upward to compress the air and force it into receivers.

The city authorities can regard such a system of compressed air power transmission only with favor. The mains need not be laid lower than three feet, and would not interfere with existing gas and water mains,

Its sanitary advantages are numerous and important:

1. The introduction of large volumes of pure air into the manufacturing parts of the city, instead of exhaust steam and noxious gases from chimneys.

2. Improved ventilation of workshops by the exhaust air from the engines.

3. Diminution of the death rate, consequent upon the general improvement of the atmosphere of the city.

4. Important abatement of smoke, by dispensing with a great number of smaller factory chimneys emitting smoke from small furnaces in which a thorough combustion cannot be obtained.

It would prove of value to the fire department, inasmuch as it could be used to operate the fire engines, thus doing away with the heavy boilers, greatly diminishing the weight of the fire engines, so that only one horse would be necessary to draw them. As these horses are very valuable animals, this factor alone would prove a saving in the city fire department. Horse, wagon, and driver for fuel supply could, likewise, be dispensed with. The very small amount of fuel necessary to heat the air in order to use it with the greatest economy could be carried on the engine. As these engines usually work under a pressure of 150 to 180 pounds of steam, an extra high pressure service pipe would have to be laid, as the pressure for industrial purposes would hardly exceed forty-five pounds

Its application to electric lighting, ventilation and refrigeration is considered in speaking of the Paris plant.

The use of the incandescent light for house lighting is to be preferred to illuminating gas, which is wasteful and has often proved fatal, not taking into consideration the uncomfortable heat, which we would gladly miss during the summer months.

A list of probable users of this economical, convenient and healthy motive power includes newspapers, printers, brewers, butchers, tailors, bakers, builders and contractors, dentists, coffee dealers, shoe factories, hospitals for ventilating, churches and concert halls for blowing organs, theaters, hotels and restaurants for ventilating, refrigerating and electric lighting.

I do not doubt that the time will come when a compressed air engine will be a requisite in every house. There is no end to the uses to which this remarkable motive power may be put, and it is only a question of time when it will be universally adopted in cities and towns.

The principle of generating motive power on a large scale at great central stations, and therefore economically, and distributing it throughout manufacturing districts to the various factories and workshops, has been much advocated by the highest authorities. Hydraulic power, electricity, and the gas engine are used to a considerable extent. They have their disadvantages, and they all impose upon the user the necessity of investing capital in new and costly plants, except in the case of entirely new works, for which new motive power engines would have to be provided in any case.

Compressed air, on the other hand, can be applied not only for motive power, but for many other useful purposes not within the scope of the gas engine, hydraulic power or electricity.

It has moreover the enormous advantage that it can be applied to the existing engines without involving any change of plant, nor imposing any expense upon the present users, who would on the contrary be enabled to dispense with their boilers and utilize the space for other purposes, also dispensing with engineer and stoker.

In place of objectionable waste products, as smoke, steam, ashes, etc., only pure fresh air would be introduced into the workshops from the exhaust ports of the engines, and there would be no nuisance of dust from stoke holes.

There would be no time lost or fuel expended in getting up steam, the compressed air being ever present, so that the engine could at any moment be started by opening a valve, and the air shut off when not required. No running down of steam, banking up of fires, slacking or removal of ashes. No wear and tear, repairs or renewing of boilers, fire bars, etc., no cleaning of flues, cartage and disposal of ashes, boiler insurance, smoke nuisance, no disastrous boiler explosions, no trouble from freezing of water pipes or bursting of steam pipes in frosty weather.

For builders' and contractors' work it would prove a most handy and convenient power. As it can be conveyed in India rubber flexible pipes, it can be used to work winches and cranes on the top of buildings in course of construction, in place of the present expensive steam traversing cranes, also for pile driving, working mortar mills, pumps and other machinery, avoiding the necessity of expensive portable engines and boilers.

It would always be ready for immediate use to drive pumps or water ejectors in case of fire, where prompt action is of greater importance than questions of cost. It would be at hand to draw foul gases out of sump holes, drains, etc., and to supply fresh air to enable men to work therein.

As compressed air in expanding after performance of work produces a rapid lowering of temperature, as low as 32° F. being easily attainable, this fact enables butchers, brewers, fish dealers, butter factors and others requiring refrigerating or cooling processes to obtain at small cost all the advantages of artificial cooling, which have hitherto only been obtainable by either a large expenditure in ice or the erection at great cost of complete ice making or cold air producing plant, entirely beyond the reach of the smaller tradesmen.

All that is required on this new system is a small engine which can be employed as a motive power engine for sundry purposes, the exhaust air from which produces the required refrigerating effect. As the engine in this case would perform a double function, a higher charge could be made for the air than if used for motive power only.

There are many special applications for which very profitable rates could be charged, such as driving hammers, ventilating hospitals, churches and theaters, supplying air for blowing organs in churches and concert halls, driving dynamos for electric lighting, all kinds of small machinery; the easy application of such a convenient and healthy power for domestic and other purposes would open up a new and wide field. It is impossible to fully estimate all the benefits to be derived from the use of compressed air.

There is one important application in connection with electric lighting which would greatly facilitate the introduction and extend the usefulness of this light of the future. At present electric light companies are obliged to lay down a costly plant at a central station, on a scale sufficient to meet an estimated demand which may or may not ever be reached and to lay large conducting wires of considerable length. Compressed air may be employed to drive small dynamo motors at convenient centers, and these can be applied anywhere from time to time as the demand increases. As the compressed air would not be much required during the night, when the electric light is most needed, nearly all the vast stored-up power laid on in the streets is available for this purpose, thus overcoming many difficulties as regards distribution over large areas, avoiding the cost of many separate stations with their attendant expenses, and opening a way to the application of electricity for private house lighting.

It is safer to count only upon the smaller class of engines as customers for the compressed air power, but even in large factories it is probable that it will be found more economical to drive each separate department or floor, or group of machinery, by a separate compressed air engine, thus saving the power expended in driving the mass of dead weight in shafting and gearing, in getting up and running down steam, etc., which in many cases would be found a full set-off against the extra cost of compressed air. The convenience, cleanliness, and healthiness of the motive power, and its peculiar advantages as regards ventilation and the introduction of pure air into the workshops, would form another strong inducement for its use in large factories.

It also involves another important advantage, viz., that in case of a breakdown only a small portion of the factory would be stopped, whereas on the present system a breakdown of the engine or boiler involves the stoppage of the entire factory.

In the case of new factories the advantages of the compressed air motive power system would be still more apparent, as it would save the first cost of chimney, flues, boilers and boiler setting, water connections, etc.

Compressed air is now widely used as a motive power. Its economical advantages are well understood and admitted and its application and uses very numerous and varied.

It has long been used for pumping, hauling, drilling, boring and other operations in mines, on a scale quite as extensive as would be presented by the streets of a moderate sized city.

It can be conveyed in pipes for long distances and in various directions with very little appreciable loss by friction, and with well constructed joints the loss by leakage is very slight.

The Mt. Cenis, St. Gothard, Hoosac, and other tunnels in Europe and America afford examples of the economic employment, in connection with the use of rock-boring machinery, of pneumatic power generated by water or steam power at long distances from its point of application.

At the Hoosac tunnel in Massachusetts, the air pressure at the compressors was 62 lb. to the sq. in., while at a distance of nearly two miles up the tunnel the pressure was only reduced to 60 lb. while the drills were in full working. At the St. Gothard tunnel the loss of pressure by friction and leakage was carefully tested. At the south end, with an absolute pressure of 5·7 atmospheres in the receiver, the pressure at the forehead, through a pipe one mile and fifteen yards in length, and 7⅝ in. diam., was only reduced to 5·5 atmospheres, or 96⅛ per cent. of the head, while eight perforators were actually at work and expending collectively 64 cu. ft. of compressed air per minute.

To ascertain the amount of leakage, the receivers and pipes were filled, the valves closed, and the compression and drills stopped. At the end of twelve hours the pressure had only fallen from six atmospheres absolute to 5·8 atmospheres, or 96⅝ per cent. of original pressure. In the middle of the tunnel, through a length of pipe about 3¾ miles, the pressure was reduced, when the perforators were at work, from 6 atmospheres absolute to 5·7 atmospheres, or 95 per cent. of original pressure.

By recent improvements in air-compressing engines their efficiency has been greatly increased, and the losses formerly regarded as inseparable from the production of this motive power have been reduced to a minimum. In many cases power may be obtained to compress air for motive power and other purposes, either by burning the ashpit and other refuse of towns as fuel, or by water power, thus saving cost of fuel, and more than compensating for losses in compressing the air.

It has been shown by Prof. Tyndall that compressed air destroys organic germs—a fact which adds a special value to it in its application to sewerage.

The fast trains on railways are controlled by a continuous brake actuated by a small air compressor on the engine, connected by a tube with every coach, and the application has been carried so far that the same source of compressed air forms a means of communication between passengers, conductor, and engineer, and also drives air through a reservoir of volatile hydrocarbon and thence into the coach lamps, where it burns with a steady, luminous flame, obviating the expense, delay, and inconvenience of oil lamps, their cleaning and changing.

The power given out by various ways of using compressed air at the driven engine is as follows:

Case 1. When the air is heated to 320 deg. F. and expanded to atmospheric pressure.
Useful effect = 58·3 per cent.

Case 2. When boiling water is available for heating the compressed air.
Useful effect = 50·3 per cent.

Case 3. When the air is used expansively without reheating, whereby intensely cold air is exhausted, which may be used for making ice, etc.
Useful effect = 38·1 per cent.

Case 4. When the air is reheated to the temperature of boiling water, but instead of expanding down to atmospheric pressure the cylinder is filled so far that the terminal pressure becomes 26 lb. absolute = 13·3 lb. above atmosphere.
Useful effect = 39·3 per cent.

Case 5. When the air is used quite cold and without expansion.
Useful effect = 27·1 per cent.

The sources of loss are:

1. Loss in raising pressure.
2. Loss by discharge of heat.
3. Loss by friction, leakage, resistance of valves in air compressing engine.
4. Loss by friction and leakage in mains.
5. Loss by leakage, back pressure, wire drawing, and clearance in driven engine.

Notwithstanding all these losses, it will be seen from the five cases given above that a useful effect remains of from 27 to 58 per cent., according to the treatment of air at the consumer's premises.

For motive power purposes, to utilize compressed air with the best economical result, it is necessary to reheat it before it enters the cylinder of the engine to be driven. Not only is the loss great by allowing air compressed to 45 lb. above atmosphere and at 60° F. to expand to atmospheric pressure as shown by case 3, where the total loss is about 62 per cent., but the temperature of the air sinks during expansion down to 14° F., a temperature at which the cylinder, piston rod, exhaust pipe, etc., would be covered with ice, the natural moisture of the atmosphere condensing and forming ice on the cold surfaces, which would in a great measure prevent the use of compressed air except for engines working without expansion.

Fortunately, however, the compressed air needs only to be heated 321° F. to avoid all these evils and to ensure its economical application. Even the best of fireplaces send off the products of combustion at this temperature as waste heat, and it is only necessary to let the supply or service pipe go through the nearest flue and expose sufficient surface to the hot gases, to obtain a very considerable increase in power at very little cost.

It is a fundamental principle that compressed air cannot give out power without losing heat, and the lost heat is exactly in proportion to the work done. If, therefore, air compressed to 45 lb. and heated to 321° F. be expanded 4·06 times, it is given out at normal pressure and temperature after having done work equal to the heat given out.

In Birmingham, England, there is a compressed air plant comprising three fine sets of air-compressing engines and a corresponding number of boilers and gas producers. Each set of compressors is designed to deliver 2,000 cu. ft. of air per minute, compressed to 45 lb. above atmospheric pressure. The present plant supplies some 3,000 horse power in compressed air to the town, but the site selected will accommodate plant for a supply of about 15,000 horse power.

In Edinburgh a plant is being put down for supplying 17,000 horse power in compressed air.

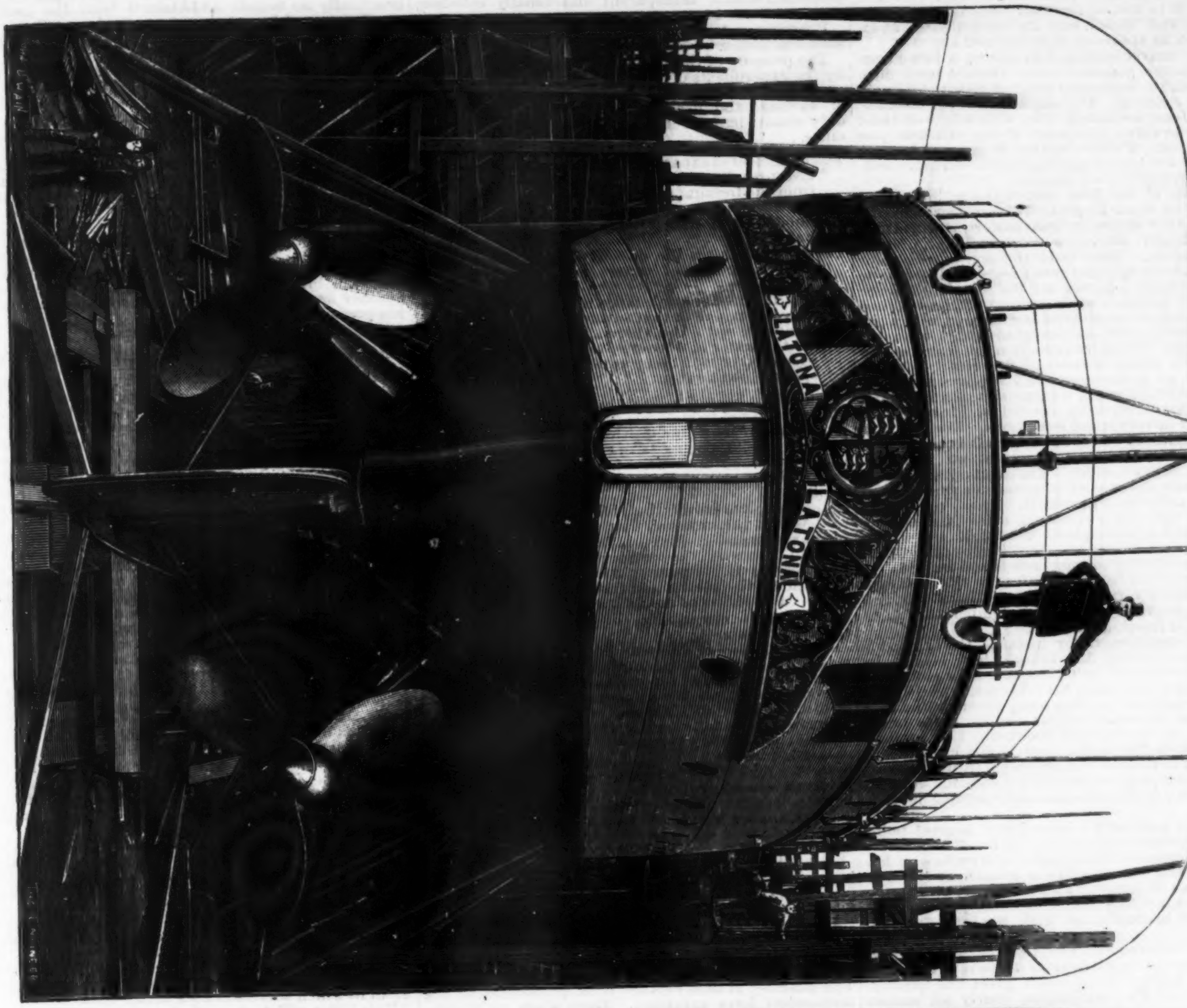
The largest air-compressing plant, for mining purposes, in the world, and one which demonstrates the feasibility of utilizing hitherto unavailable sources of power, is that of the Hydraulic Power Co., of Michigan. There is a sudden drop in the bed of the Menominee River forming what is called the Quinnesec Falls, and furnishing unlimited power. It is at this place that the Rand Drill Co., of New York, erected for the mining company an air-compressing plant consisting of four pairs of compressors, each pair being run by its own independent turbine wheel. The mine, however, where the air is utilized, and to which it is conducted by a 24 inch main, is situated three miles from the compressing plant, and the whole furnishes a brilliant solution to the problem of utilizing the enormous power of waterfalls which have as yet not been available for that purpose. It certainly would be much wiser to use the power of Niagara and St. Anthony Falls in this way, bringing at the same time the pure air of the falls into the manufacturing districts, than in converting their power into electricity, to be transmitted through death-dealing wires.

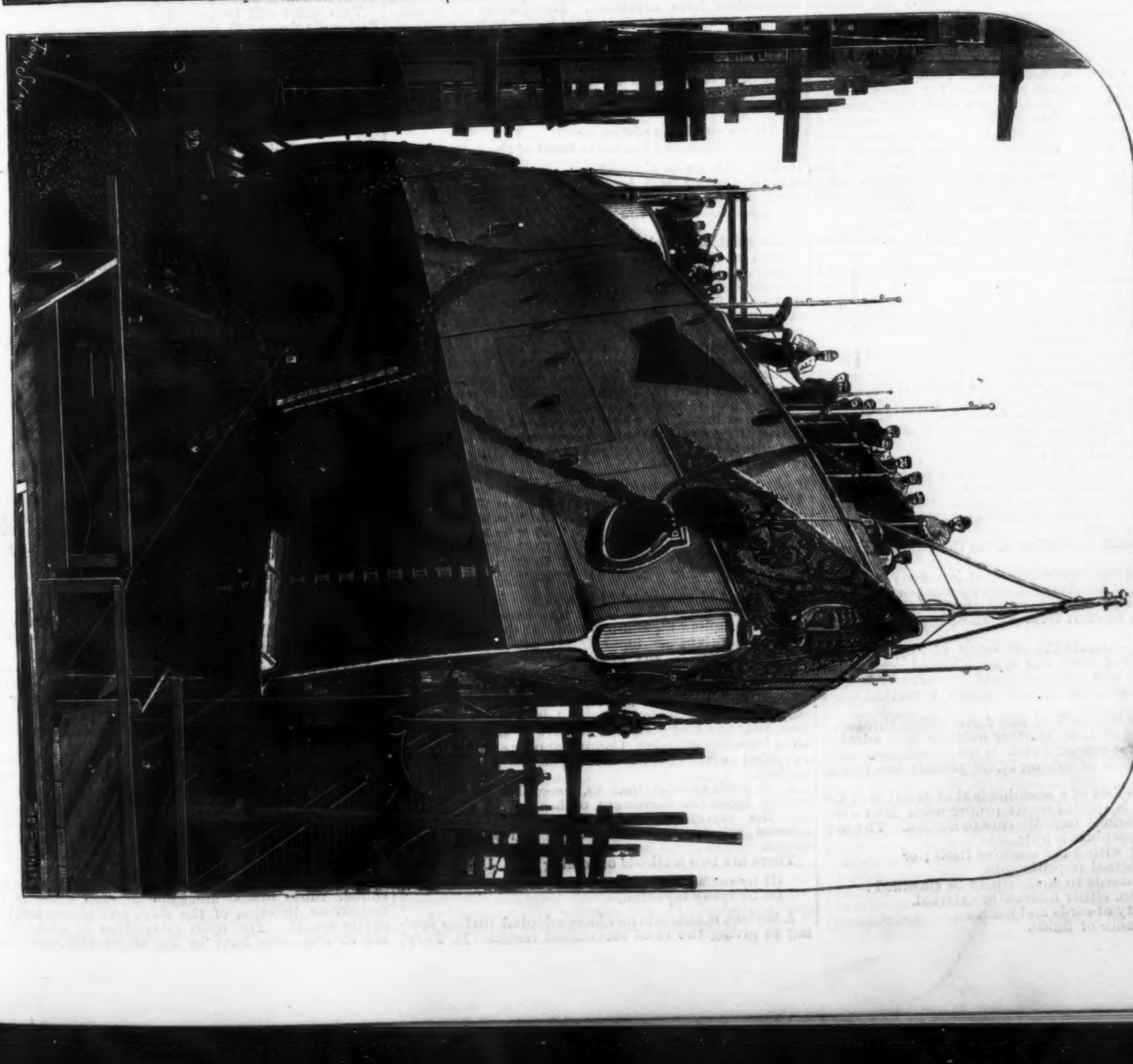
In Paris, France, the transmission of power by compressed air has been in operation on a large scale and with the greatest mechanical and financial success for a number of years. The plant furnishes 3,000 horse power in compressed air, which is used during the course of the day in three distinct services: (1) During the day time in the distribution of motive power to manufacturers. (2) In the evening for the production of electricity for lighting. (3) During the twenty-four hours for actuating pneumatic clocks. The whole plant occupies an area of 107,500 sq. ft., two-fifths of which are covered by buildings. The plant consists of ten steam engines for compressing the air, twenty-two air compressors and thirteen boilers. All the compressors united take from the atmosphere more than 17,000,000 cu. ft. of air per day, in order to distribute it in Paris under pressure in the form of motive power, electric lighting, ventilation, refrigeration, hoisting, etc. One can easily see of what enormous benefit this must prove, especially to the manufacturing districts where it is distributed, when all this amount of fresh air is introduced into the various workshops, not only ventilating but producing a refreshing coolness, and the sanitary value of such a power can hardly be estimated.

The air is conducted from the works by a 12-inch main and is at the present time distributed over the district comprised between the boulevards and Rue de Rivoli. The works are situated nearly five miles distant from the farthest end of the mains. So great has been the demand for this power that a duplicate main is being laid throughout, and new engines and compressors are being pushed forward as rapidly as possible.

The result of detailed investigations made by Alex. B. W. Kennedy, F.R.S., Prof. of Engineering in University College, London, goes to show that the compressed air transmission system in Paris is now being carried on, on a large commercial scale, in such a fashion that a small motor nearly five miles away from the central station can indicate in round numbers ten horse power for twenty indicated horse power at the station itself. This can be reached by any motor of between five and twenty-five horse power, while smaller motors would work somewhat less economically.

A system of transmission which is actually being carried out on a large commercial scale in such a way as to have an indicated efficiency of fifty per cent. be-





STERN AND BOW OF HER MAJESTY'S PROTECTED CRUISER LATONA.

tween prime mover and secondary motor, four or five miles apart, is one which needs no adventitious aids to commend it to notice, especially when its uses are so numerous and varied, and its conveniences so extremely great, as are those of compressed air.

The great convenience and handiness which a compressed air motor possesses have already been mentioned. From the engineer's point of view these qualities are most striking. The engine starts, for instance, without the least hesitation even with full brake load on, directly the valve is opened, if the crank is just past the center. This, of course, is impossible with a gas engine, and hardly less impossible with any ordinary single cylinder steam engine.

The absence of the heat and leakage, noise and smell, which so often in greater or less degree accompany the smaller steam or gas motors, constitutes a very much larger difference than could at first be thought possible. But from the consumer's point of view the advantages are even greater than from the engineer's. There is, first of all, the complete absence of danger and nuisance of every kind. There is then the great saving of space, even as compared with a gas engine, and much more as compared with a steam engine and boiler. There is reduction of insurance on account of the entire absence of fire risk. Not only this, but the air motor completely supplies that most important industrial want, a motor suitable for "small industries," that is, for work carried on in workmen's own houses or in very small workshops. For here it is not only mechanically most suitable, but in the nature of things it can be made to cool or ventilate, by its exhaust, to any desired extent. The sanitary advantage of this, in cases where work is carried on in confined spaces, can hardly be exaggerated.

Even in a very large printing office in Paris an almost unbearable atmosphere was made quite pleasant as long as the motor was working, by allowing a portion of the exhaust to come into the room.

By using air direct from the mains in the motor, or by heating it only very slightly, the exhaust air can be, of course, so greatly reduced in temperature as to be available for freezing purposes.

In one Paris restaurant, for instance, the exhaust is carried through a brick flue into the beer cellar. In this flue the carafes are set to freeze, and large moulds of block ice are also made for table use, while the air is still cold enough in passing away through the beer cellar to render the use of ice for cooling quite unnecessary, even in the hottest weather. The nominal function of the engine in this case is the charging of batteries used in the electric lighting of the restaurant. The conjoint use of power and cold is common in Paris, the power being in this case generally applied in electric lighting.

While in any large city it is no doubt a great point that by a compressed air system the handiest possible cooling appliances can be brought everywhere within reach, in tropical climates this is something of necessity rather than of luxury. This possibility of "laying on" cold air in hot climates is, of course, a most important matter in connection with the future of compressed air.

Most of the compressed air in Paris is used for driving motors, but the work done by these is of the most varied kind. There is a list which gives the locality, use and power of 225 installations, nearly all motors working at from ⅛ horse power to 50 horse power, all driven from the central station and the great majority of them more than two miles away from it.

In a number of cases, as at the Eden Theater, Theater des Varieties, office of the *Petit Journal*, etc., the motor drives dynamo machines for electric lighting. In the offices of the *Figaro* and *Petit Journal* large motors are used for printing, and there are many small printing establishments also worked by compressed air. Among the smaller industrial purposes for which the air motors are used in Paris, we find the driving of lathes for metal and wood, of circular saws, shearing machines, drills, polishing machines, and many others. They are used also in the workshops of carpenters, joiners, and cabinet makers, smiths, umbrella makers, collar makers, book binders, and naturally in a great many places where sewing machines are used, by dressmakers, tailors and shoemakers, and from the smallest to the largest scale. They find application also in all sorts of industrial work, with confectioners, coffee roasters, color grinders, billiard ball makers, in many departments of textile industry and other matters too numerous to mention.

There is one particular instance of variety of application which is very interesting. At the "Montagnes Russes" there is a large horizontal engine placed in a recess driving a dynamo and cells for the electric lighting of the whole building; a small vertical engine in another part worked the rotary pump which actuated the "cascade;" two or three large air-driven fans in wooden shafts serve for ventilation; and, lastly, a simple connection on a flexible pipe threw the air pressure into the beer barrels as they were brought in, and transferred their contents to a height from which they could afterward descend by gravity to the place where they were required.

In an appendix the author gives the following items of interest:

No machine can create power; it is merely an inert instrument for the advantageous application of power, and by means of which a force applied at a certain point is made to exert force at another point, more or less distant.

In order to estimate the efficiency of any force, an arbitrary unit of work has been adopted, called the foot pound, which is the mechanical value of a force capable of raising one pound through a vertical space of one foot.

To estimate the work of any force acting through a limited period of time, another unit has been adopted called the horse power, which is the mechanical value of a force capable of raising 33,000 pounds one foot in one minute.

The useful effect of a machine is that fraction of the power which is applied to its proper work after overcoming the various impediments to motion. The useful effect of machines is lost:

(1) Either within the machine itself; or
(2) By external impediments.

The impediments to motion may be classified:

(1) Friction, either internal or external.
(2) Rigidity of cords and belts.
(3) Resistance of fluids.

Aeriform bodies are fluids which are highly compressible, elastic, transparent and usually colorless; they are divided into vapors and gases.

Pneumatics treats of the mechanical properties of aeriform bodies.

The pressure of the atmosphere was first ascertained by the experiments of Torricelli, in 1643. At the level of the sea it is equal to 14·7 pounds to each square inch of surface, and decreases with the height, being only about half as much at an elevation of three miles.

The coefficient of expansion is the small fraction which measures the expansion of a body on being raised from the freezing point to one degree above. The rate of expansion for all gases is very nearly the same, being 1-490·9 of their bulk for each degree Fahr.

The thermal unit is the quantity of heat required to raise one pound of water from 32 to 33 degrees Fahr.

The specific heat of a substance is the heat required to raise one pound of that substance one degree Fahr. compared with the thermal unit. The specific heat of water is, of course, taken as 1·00. With the exception of hydrogen, water possesses the highest specific heat known.

The latent heat of a liquid substance is the amount of heat required to melt one pound of that substance after it has reached the melting point.

After a solid begins to melt, the temperature remains constant until the whole is melted, and the temperature of a liquid remains constant during ebullition.

The temperature of the boiling point of water increases with the pressure, that is to say, variations of pressure increase or diminish the boiling point, because a liquid boils when the tension of its vapor is equal to the pressure it supports. At the pressure of the atmosphere the boiling point of water is 212 degrees Fahr., and is considerably reduced on ascending mountains, in consequence of the diminished atmospheric pressure.

Equal volumes of different liquids produce unequal volumes of vapor; water furnishes, bulk for bulk, a greater amount of vapor than any other liquid; although the latent heat of water is greater than that of other liquids, and the cost of fuel in generating vapor would be in proportion to the latent heat for equal volumes, yet experiments show that for equal volumes the latent heat of these liquids is not far different, and there would be, therefore, no economy in using other liquids in place of water in the steam engine, even if they cost no more than water.

The standard adopted for the horse power of boilers is 30 lb. of water per hour, evaporated, at 70 lb. pressure, from 100° F., for each horse power.

A standard U. S. gallon of water contains 231 cubic inches and weighs 8⅓ pounds.

A cubic foot of water contains 7½ gallons and weighs 62½ pounds.

In all cases of friction, compression, and percussion a certain amount of mechanical force is arrested, the energy of its visible motion is spent in producing molecular motion, and is thus transformed into heat. The quantity of heat evolved is in proportion to the mechanical force expended. Thus, when air is compressed, the rise in temperature is due to the mechanical effect or work which must be spent in driving the particles of air nearer together. Conversely, heat is consumed in effecting mechanical work. Let a cylinder filled with compressed air be cooled to the temperature of surrounding bodies. Its elastic force is competent to produce work—

(1) by moving a piston, or
(2) in displacing the air in front of the cylinder.

If, now, this air be allowed to expand into the atmosphere, the air will be chilled, because mechanical work has been performed by the expenditure of the heat to which the elastic force of the air was due.

The relation which exists between heat and work is known as the mechanical equivalent of heat, or, simply, as Joule's equivalent, because Joule first determined the mechanical equivalent of heat by the friction of fluids. He found that the average of many experiments gave 772 foot pounds as the mechanical equivalent of the heat required to raise one pound of water one degree Fahr., and as this quantity of heat has already been designated as the thermal unit, hence heat and mechanical force may be exchanged, one for the other, in the ratio of 772 foot pounds for one thermal unit.

The heating of air when compressed is an illustration of the general law of the conversion of mechanical power into heat. The extent of this heating is shown in the following table:

Temperature of air before compression	= 60	degrees F.
Temperature of air compressed to 15 lb.	= 177	"
" " " " 30 "	= 255	"
" " " " 45 "	= 317	"
" " " " 60 "	= 369	"
" " " " 75 "	= 416	"
" " " " 90 "	= 455	"

This heat of compression is a factor of the utmost importance and must be taken into careful consideration in designing air compressors. If the air could be used in an engine immediately after compression, before the loss of any heat, and perfectly expanded back to atmospheric pressure, its efficiency, leaving friction out of consideration, would be 100 per cent. We cannot, however, prevent the loss of heat after compression and before use, and it is evident, therefore, that the best plan is to remove it as fast as possible from the cylinder. Compressors are consequently provided with cooling arrangements more or less perfect.

It is evident also that as, according to the preceding table, the increment of heat is greatest during the early stages of compression, the cooling process should be most active during the early stages.

There are two methods of cooling:

(1) by surface cooling.
(2) by spray injection.

American manufacturers have adopted surface cooling as giving the most economical results. In Paris, although the cooling water is used in such a way that practically no benefit is obtained from the cooling, an efficiency of 50 per cent. is realized, and it is easy to see that with compressors of American manufacture the efficiency would be materially increased, thus enhancing the value of a compressed air plant in this country.

An underground cable road has been planned to run up to the summit of the "Jungfrau," one of the grandest mountains of the Alps and about 2½ miles high.

The road is to be divided into four sections. Each section will be provided with an independent hoisting engine, which will be operated by compressed air, the air compressors for supplying air to all the engines being placed at the base of the mountain. The compressors will also supply air for working the rock drills and boring machinery and for ventilating the tunnels while the road is being built. The whole will be a brilliant example of engineering skill and another demonstration of the power and utility of compressed air.

NEW PROJECT FOR A SHIP RAILWAY.

The question of carrying ships by railway is older than is usually supposed. As long ago as 1855, Mr. Gatineau, as a proof of priority, deposited at the Versailles Tribunal of Commerce a memoir entitled: "A Rapid Glance at and an Epitome of a Project for Carrying Ships of all Sizes, with their Cargoes and Rigging, by Railways and Steam Engines, applicable in a large Number of Circumstances." Mr. Gatineau's project was to have been applied to the carriage of ships from Havre to Paris. It presents a great analogy with the one that Capt. Eads has since proposed for crossing the isthmus of Tehuantepec. In both cases, it is a question of effecting the removal of a ship from the water by means of a floating dock, and then drawing it into a sort of supporting cradle resting upon a car, which, hauled by locomotives, runs upon parallel iron tracks. Terra firma is thus traversed as far as to the terminal point, where, through an operation just the reverse, the ship is put into the water again.

At the instance of Mr. Brundelys, it had already been proposed in England in 1859 to employ an analogous system for the passage of the Isthmus of Suez. Three years later, in 1862, the directors of the scientific exploration of the Isthmus of Darien thought of making an application of a railway of this nature, and in 1872, Mr. Sebillot, formerly engineer in chief of the arsenal of Foo Choo, China, published a memoir in which he set forth the advantages that would be found in traversing the Isthmus of Panama by means of a ship railway.

Mr. H. G. C. Ketchum, a Canadian engineer, is the author of a project, now in the course of execution, that will allow the largest ships, transferred to a railway, to cross the Isthmus of Chignecto (Nova Scotia), which separates the Gulf of St. Lawrence from the Bay of Fundy. This isthmus is 16 miles in length. The railway will connect Amherst on the Bay of Fundy with Tidmish on the Gulf of St. Lawrence.

At Amherst the ships will enter a small basin closed by a tide gate and communicating with a second basin in which there will be a lifting dock.

This latter will be provided on each side with ten hydraulic presses 25 inches in diameter with a maximum stroke of 40 feet. The piston heads will be connected with the cross pieces of the dock by steel chains. The dock will be 230 feet in length by 60 in width, and will be provided with a double track of normal gauge, designed to receive the wood upon which the ship will rest.

As the variations in the level of the sea at Tidmish do not amount to much, the outer basin will be suppressed. A channel will simply be dug, and be protected by stockades. The lifting dock will be the same as that at Amherst.

The line that connects these two ports is a straight one, and consists of a double steel track with rails weighing about 37 lb. to the running foot.

Work was begun at the close of 1888 by Mr. Ketchum, who has associated with himself, in the capacity of consulting engineers, Sir John Fowler and Sir B. Baker, the celebrated builders of the bridge of Forth.

At present, it appears, more than half the work is finished, and there is some talk of opening it to traffic at the end of the present year.

The construction of ship railways has therefore emerged from the domain of theory, and the results that it makes us hope for have turned the attention of eminent men toward it, and among these, in addition to those whom we have just cited, may be named Mr. William Smith, engineer in chief of the port of Aberdeen, who is the author of a new project that our readers will feel obliged to us for making known to them.

Mr. Smith, struck by the inconveniences presented by the different systems hitherto proposed, and which consist especially in the use of rigid carriages and consequently of railways with very slight gradients, without curves, the changes in direction being effected by means of complicated turn tables, has endeavored to render it possible to carry ships overland without altering the direction line of ordinary railways.

The essential points of his project, as he recently explained it before the members of the London Chamber of Commerce, are as follows:

1. The keeping of the ship afloat upon the transshipping carriage by means of a quantity of water representing but a slight per cent. of the weight of the vessel.
2. The rendering of the carriage flexible vertically, so as to utilize the normal gradients.
3. The rendering of the rolling base flexible laterally in order to employ curves, switches and shunts upon the multiple line of the ship railway.

According to Mr. Smith, the preceding desiderata will be realized by a combination of hydraulic cushions, of sectional carriages with movable sides, and of compound bogies.

We shall briefly describe each of these elements.

The hydraulic cushions are formed of iron plate and rubber tubes placed alongside of each other in the transverse direction of the ship, and throughout its entire length. The open extremities of these tubes are at the same level as the ship's deck, and their

middle part, passing around the keel, rests upon the carriage platform. These tubes as a whole, then, constitute a reservoir divided into independent bands in which the water rises to the same height as the water line.

As the pressure in the interior of the hydraulic cushions cannot exceed that which is due to the immersion of the ship, say about 13 pounds per square inch for the largest vessels, the cushions are never filled with water much above the level of their horizontal part when they are not supporting the ship. When the carriage is not loaded, the water contained in the tubes is at a level of from 12 to 20 inches, for example, which would be equal to an internal pressure of one pound to the square inch. When the ship is placed upon the carriage, and consequently upon the hydraulic cushion, its weight compresses the central part of the tubes and causes the water to rise in the vertical parts. The pressure of the water in the tubes is then counterbalanced by the total weight of the ship on the one side and the resistance of the carriage and cushion on the other. This pressure of the water upon the interior of the tubes can never be high enough to burst them.

The weight of water necessary in the cushion to keep the ship afloat can be reduced to 5 per cent. of the vessel's weight, with a carriage in good condition.

When the carriage is moving over an incline, the effect of the hydraulic cushion is to keep the vessel afloat throughout its entire length. If the water were contained in an ordinary reservoir, it would naturally flow toward the lowest point and would leave one of the extremities of the vessel exposed.

The carriage consists of several segments so united as to permit of a motion or rather a certain flexibility in the vertical direction, so that with a very slight elevation or depression of the level of the water in the hydraulic cushion, the rigidity of the ship is compensated for when it is on a slope. The water rises and falls successively, and thus produces a sort of wave, keel. The sides of the carriage, which have been temporarily lowered, are raised, and the ship takes a position of equilibrium upon the cushion. The passage over land is afterward effected without any stoppages except those required at the stations for taking aboard or discharging goods.

At the terminal point, the setting of the vessel afloat is performed very simply by lowering the sides of the carriage at the moment that it reaches the lower end of the inclined plane, and the ship leaves the cushion as soon as it has sufficient water to float.

By the introduction of curves and gradients upon ship railways, and the use of a flexible carriage like the one just described, it is possible to effect the carriage of ships under all the circumstances in which an ordinary railway can be established. There would, therefore, be no large commercial or manufacturing city that would not be capable of becoming a first class port.

According to Mr. Smith, the advantages of this system of carriage, from a mechanical standpoint, are as follows:

The vessels are always afloat; the carriage is flexible in a vertical direction; the rolling base is flexible in a horizontal direction; the hydraulic cushion cannot be cut or damaged; the carriage can be quickly adapted to the dimensions of any ship whatever; the ship is taken from the water or set afloat again without difficulty; there is no jarring motion communicated to the ship by the rolling of the carriage; the use of locks, elevators and turn tables becomes unnecessary; and, finally, the line can be enlarged economically.

From the advantages that Mr. Smith's system presents from a technical point of view, there naturally result corresponding advantages from a financial standpoint. According to him, the carriage of merchandise by a ship railway must be much cheaper than by any other mode.

Mr. Smith, to whom we must leave the responsibility for the figures that he advances, has drawn up some approximate estimates as to the cost of ship railways as

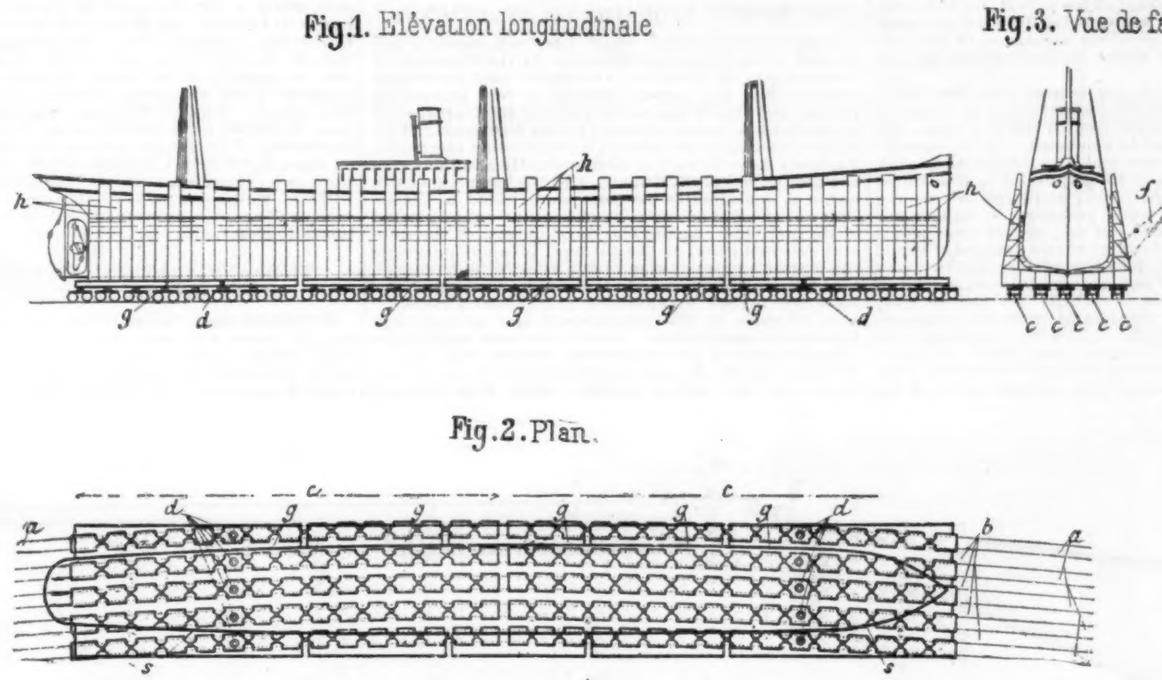


FIG. 1.—Longitudinal Elevation. FIG. 2.—Plan. FIG. 3.—Front View.

DIAGRAM OF FLEXIBLE CARRIAGE FOR SHIP RAILWAYS.

which runs along the row of tubes when the carriage is rolling over a change of gradient.

The displacement of the ship, although perfectly free, is not very pronounced in the vertical direction, and, as it produces no sliding upon the cushion, the latter cannot be cut.

The bottom of the carriage consists of a flexible platform which rests upon two trains of trucks upon each track, that is to say, that for five tracks (such is the case in our engraving, Fig. 3) there are ten trains of compound trucks or bogies. These bogies offer the peculiarity that as the two trains of trucks are connected, and capable of lending themselves to a lateral motion, guided upon the rails by the flanges of the wheels, each train is connected with the platform of the carriage, through the intermedium of one of the trucks, only by means of a single pivot.

The carriage, then, combines the ten trains of trucks, and at the same time permits them to follow the curves of the track upon which they are directed by the flanges of the wheels, and the rails serve as guides to the trains of trucks, which they maintain in position under the carriage that they support.

As these jointed trucks allow the railway to describe curves, as in ordinary railways, they permit of dispensing with turn tables, which have to be used on the Chignecto railway. A five-track line can be utilized by a flexible carriage capable of receiving a ship 270 feet in length, with a cargo of 2,000 tons.

The following is the mode of putting a ship upon the carriage: The extremities of the track terminate at a submergible inclined plane which resembles those that have been installed on some canals at the junction of reaches separated by considerable heights of fall. The vertical sides of the carriage are formed of several sections that are capable of turning around the platform through the aid of hinges. When it is desired to place a ship upon the railway, the tubes above mentioned are placed side by side upon the bottom of the carriage, so as to form the hydraulic cushion upon which the ship is to rest; then the carriage is lowered upon the inclined plane, so as to bring it right under the vessel's compared with that of maritime canals, existing or in course of construction. These figures are as follows:

Canals.	Length, Miles.	Ship Railways.	Canals.
1. Tehuantepec	125	$4,000,000	$13,000,000
2. Panama	40	3,000,000	37,500,000
3. Lakes Erie and Michigan	164	5,500,000	17,000,000
4. Lake Ontario and Georgian Bay	67	2,500,000	7,000,000
5. Isthmus of Suez	87	3,000,000	9,500,000
6. Rouen and Paris	63	2,000,000	5,120,000
7. Forth and Clyde	17	1,000,000	3,120,000
8. Tyneside	96	3,240,000	11,000,000
9. Stockton and Darlington	53	1,620,000	....
10. Humber and Mersey	106	3,740,000	12,500,000
11. Mersey and British Channel	170	5,000,000	15,000,000
12. Leeds and Northampton	111	3,760,000	......
13. London, Northampton and Birmingham	124	4,000,000	....

Let us say, in conclusion, that a working model of this new system of ship railway is established at the Edinburgh exhibition, of which it certainly constitutes one of the principal curiosities.—*Annales Industrielles.*

THE GIFFARD GUN.

FOR some little time past a considerable amount of interest has been evinced on the Continent, and is now being awakened in this country, in respect to a gun in which the propelling agent is liquefied gas. It is the invention of M. Paul Giffard, a French engineer, whose name is well known in all engineering circles, and who has been at work intermittently upon the principle of this gun for the past 25 years. As now brought before the public, the gun is simplicity itself, but this simplicity has not been arrived at without long and anxious thought, nor without many changes and variations upon M. Giffard's original conception. The principle, however, has always remained the same, and it is the gradual development of that principle into practice which has occupied M. Giffard's time and has at length apparently been crowned with success.

The principle consists in the manufacture and liquefaction of carbonic acid gas so that it can be safely stored up within a very small compass and will give out 500 lb. pressure per square inch when liberated for actual use. In carrying this principle into practice the liquefied gas is contained, under a high pressure, in a metallic tubular reservoir about 9 in. long, which is fixed under and in a line with the barrel of the gun, and which is conveniently grasped by the left hand in firing. Although containing an immense store of power, there does not appear to be any danger in a weapon thus equipped. In the first place the reservoir is made of Siemens-Martin steel of the highest quality, so that a burst is hardly possible, and in the second, should a flaw in the metal lead to a fracture, the gas would simply escape much in the same way that it does on the opening of a bottle of soda water. Then, the quality of the metal used for the gas receiver is such that it will stand rough usage without liability to fracture. It may be, and, indeed, it has been, knocked greatly out of shape when full of gas without any prejudicial result arising, the gas having been afterward used for discharging projectiles from the gun.

So much for the special character of the propelling agent, liquid gas, which takes here the place of powder. We now come to the method of utilizing this stored up ballistic power. In practice the bullet is dropped into a small aperture at the rear end of the barrel, and by moving a small lever it is deposited in the breech chamber of the gun. The hammer of the gun is then placed at full cock and the trigger pulled. By the fall of the hammer a pin is struck which opens a valve at the rear of the liquefied gas reservoir and permits the instantaneous escape of a sufficient volume of gas for one discharge. The bullet is thus ejected with a force proportionate to the impelling power of the charge, which can be increased or decreased at pleasure by a simple screw arrangement. In other words, the propelling power is completely under control, although, of course, this in practice is not left to the arbitrary will of the ordinary user, but will be fixed and definite, according to the character of the gun in which it is employed. The discharge of the gun is unaccompanied by any report, nor is there the least recoil or kick. On pulling the trigger there is a slight hiss or puff, followed by the noise of the impact of the bullet upon the iron target. The reservoir is very light and, when charged with liquefied carbonic acid gas, is capable, according to the size and caliber of the gun, of discharging from 100 to 500 consecutive shots at a stated cost of less than one penny. It is stated that there is no fear of any part of the gun or its mechanism becoming oxidized by the gas, and it is hardly necessary to add that there is neither smoke nor smell from the propellant. There is also no deterioration of the liquefied gas from storage or keeping. With regard to the rifle itself, with the exception of the tubular reservoir carried under the barrel, there is no material difference in appearance between the Giffard gun and an ordinary weapon of similar character.

A demonstration of this new gun was recently made at the headquarters of the London Scottish Rifles, James Street, Buckingham Gate, London. A large number of the members of both Houses of Parliament and other gentlemen were present, including the Duke of Roxburghe, Lord Grimston, Lord Dunsany, the Rt. Hon. E. Marjoribanks, M.P., Admiral Field, M.P., Col. Saunderson, M.P., Colonel Waring, M.P., Col. Laurie, M.P., Col. Kenyon-Slaney, M.P., Sir George Baden-Powell, M.P., Col. Strachey, Capt. B. T. L. Thomson, and Mr. J. Stewart Wallace. The proceedings were commenced by M. Giffard explaining the principles and practice of his system, after which he discharged a number of rounds from saloon rifles of six, eight, and ten millimeters caliber respectively. The visitors were then invited to try the new rifle, which many of them did with satisfaction. The demonstration went to show the valuable nature of the invention and to prove the soundness and practicability of the

principle. Of course, the proof was limited to the arms referred to, but it was stated that the principle has been applied in France to military and sporting guns, as well as to revolvers and pistols with every success. It was also stated that Colt's Company in America are applying the principle to their arms. On the whole, it was shown that M. Giffard has now practically developed a very important principle, which only awaits application to the various weapons in use for throwing projectiles. It is said that the French government is at present engaged in investigating the merits of the invention as applied to artillery, in which direction some excellent practice at long ranges has already been made. —*London Times.*

THE GIFFARD GUN.

THERE is much talk just now about a gun invented by Mr. Paul Giffard, in which liquefied gas is used, and which may possibly make a new revolution in munitions of war. We have, consequently, thought that it would prove interesting to our readers if we gave a description of this weapon, from the inventor's patents. The charge of liquefied gas, which replaces powder, is inclosed in a steel capsule, *f*, made fast to the barrel and screwed at *m* into the butt. This capsule terminates behind in a valve, *g*, pressed by a spring and the gas against a hard rubber seat, *h*, and provided with a rod, *j*, that traverses, at *f*, a tight packing, *i*, of soft leather. A rubber packing, *l*, secures, on another hand, the tightness of the threading, *m*.

As soon as the trigger is pressed, the hammer strikes the extremity, *p*, of the rod, *j*, and, through its impact, thrusts the valve, *g*, to a distance regulated by the stop, *e*. There then escapes through *c* a certain quantity of liquefied gas, which expels the projectile that has previously been introduced into the barrel through a sort of cock, *d*. As for the valve, *g*, that is at once closed by the pressure of the liquid.

According to Mr. Giffard, the reservoir, *f*, might, with liquefied carbonic acid, serve for from 300 to 500 consecutive shots, "owing to the formidable power that it develops on passing from zero to 300 deg.," and further on, in another passage of his patent, he adds that "the mild and gradual action of the liquefied gas upon the projectile, with a previous expansion of from 100 deg. to 300 deg., brings about ballistic effects that are essentially new."

These considerations do not appear to us very clear. We do not see how, in this application of liquefied gases, temperatures of 100 deg. to 300 deg., that Mr. Giffard speaks of, would be produced. In the capsule, *f*, we see merely carbonic acid at a temperature of 30 deg. at the most, that is to say, under a pressure of about ten atmospheres. Now, although we do not know exactly the total work necessary to liquefy one gramme of carbonic acid, we can, nevertheless, assert that the total potential energy of one gramme of liquid carbonic acid ought not to exceed one-thirtieth of a kilogramme. That of one gramme of gunpowder is about 200 kilogrammes, of which we can scarcely utilize, at the most, more than $\frac{45}{100}$, or 90 kilogrammes. We do not see, then, *a priori*, how the liquid carbonic acid can exert a power greater than that of ordinary powder, as Mr. Giffard supposes, and it is permissible to have a little doubt upon this subject, while at the same time wishing the invention a most brilliant success.

Mr. Giffard proposes also, for blasting in mines, to replace the ordinary cartridges by capsules of liquid carbonic acid, that would be exploded by the detonation of an explosive cartridge in the interior of the capsule. It seems as if these capsules might, in mines subject to the presence of fire damp, offer guarantees of security that are worthy of attracting attention.—*Revue Industrielle.*

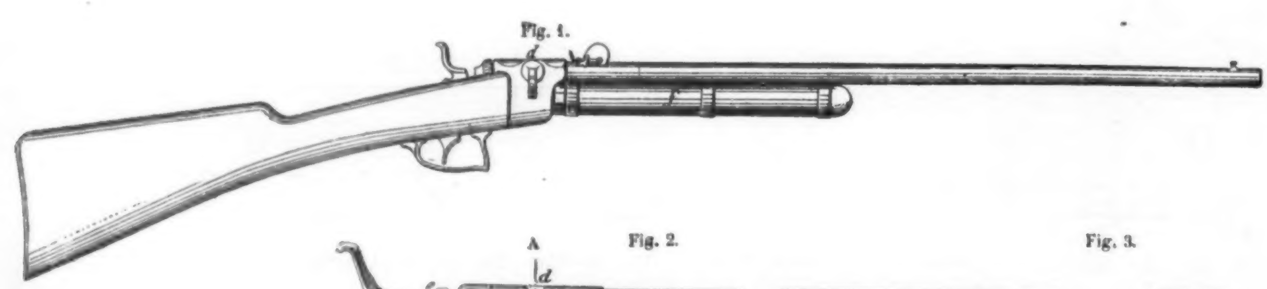
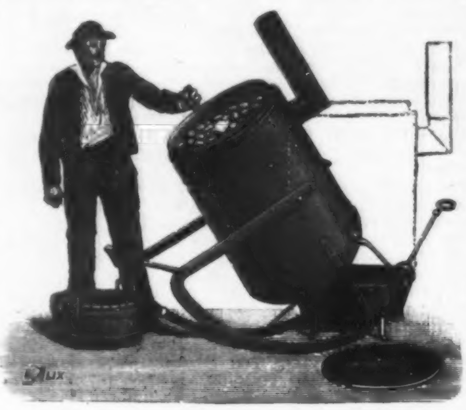


FIG. 1.—Side Elevation. FIG. 2.—Longitudinal Section. FIG. 3.—Cross Section at A B. FIG. 4.—Section of the Carbonic Acid Receiver. FIG. 5.—Section at C D.

THE NEW CARBONIC ACID GUN OF M. GIFFARD.

APPARATUS FOR BOILING POTATOES.

THE apparatus herewith illustrated will prove convenient for use on farms where large quantities of potatoes have to be boiled. Its prominent feature is the ease with which the boiler can be emptied when the vegetables are cooked. The dotted lines show the position of the apparatus during the operation of boiling. As soon as the latter is finished, the lever at the side of the boiler is pulled, and the latter turns upon two rockers and takes the position shown in perspective. Upon continuing to act upon the lever, the boiler



APPARATUS FOR BOILING POTATOES.

is sufficiently inclined to allow the potatoes to make their exit.—*Les Inventions Nouvelles.*

THE RIBBON INDUSTRY OF ST. ETIENNE.

IN a communication which has been recently addressed to the French government by the Chamber of Commerce of St. Etienne, it is stated that the ribbon industry has just passed through a very prosperous period, and that it has never enjoyed such prosperity as has been witnessed during the last four years. This prosperity may be attributed to more than one cause. Fashions have always a preponderating influence on the production of St. Etienne, and the low price of silk has in a considerable measure contributed to the activity of the ribbon industry in facilitating the placing of its products. Again, the development of the general well-being and of the national prosperity permits the masses to use articles which were hitherto considered as luxuries reserved to the well-to-do classes. The economic regime inaugurated in 1860 had a considerable influence on the development and prosperity of the ribbon manufacture. One of the most remarkable consequences of the commercial treaties was the enabling of the St. Etienne manufacturers to import and utilize the fine cotton threads which were virtually prohibited up to that period, and which the French spinning factories produced badly, if at all.

It was in 1860 that cotton entered into the texture of velvet ribbons, and many other articles of the ribbon industry, which permitted a considerable development of its exportation. This development would have been much more important, if by the treaties exaggerated duties had not been maintained on cotton and silk threads. The treaties of 1860 were made on the eve of the secession war in the United States. This country, which used to place at St. Etienne orders amounting to 30,000,000 francs yearly, discontinued its orders all at once. The manufactures of St. Etienne are exported over the entire world. The exportation is effected by French and foreign commission houses established at St. Etienne, and by the manufacturers directly, as well as indirectly by Paris firms. Until late years the exportation was chiefly in the hands of commission houses, but within the last few years the course of business has been modified, owing to the increased facilities of communication. The Chamber of Commerce states that it is difficult to accurately estimate the proportion of goods exported from St. Etienne to that of goods manufactured, because of the indirect exportation effected by the Paris houses. It may, however, be confidently asserted that seventy-five per cent. of the goods manufactured find their way abroad, while the remainder, or twenty-five per cent., are destined for home consumption. The exportation from St. Etienne direct represents about fifty per cent., while that from Paris may be estimated at twenty-five per cent. The value of silk used by the St. Etienne manufacturers during the year 1889 may be estimated at 61,000,000 francs; cotton and India rubber, 5,000,000 francs; making a total of 66,000,000 francs, or £2,640,000. The cost of the raw material may be estimated as constituting sixty-four per cent. of the cost of production of St. Etienne ribbons. From this it results that the entire value of the ribbons produced during the year 1889 amounted to about 103,000,000 francs, or £4,120,000. The silk employed in the manufacture of ribbon is almost entirely of foreign production, as statistics show that within the last twenty-nine years only ten per cent. of native silk has been used, and the average has even fallen to six per cent. within the last ten years. The great perfection to which China and Japan have brought silk cultivation, and the low prices of the silk, account for this increase in the consumption of the foreign product to the detriment of the home product. The Chamber of Commerce, therefore, thinks that to interfere with the present rates of import duties on foreign silks would be productive of the gravest results. The slightest increase of these duties would, it is said, cause a displacement of the silk markets from Lyons to London and Milan, and would also probably benefit some German town. Concerning the organization of the ribbon industry of St. Etienne, it is said that it employs 21,000 looms, of which 17,000 are the property of the workmen, on which they work at their own homes. These 17,000 looms represent a capital of from 25,000,000 to 28,000,000 francs (from £1,000,000 to £1,120,000). The number of men and women employed on these 27,000 looms exceeds 63,000. At the side of the weaver there is a complete organization of artisans, without which the ribbon industry could not exist, such as dyers, silk dressers of various kinds, manufacturers of looms, etc.

THE APPLICATION OF FRIGORIFIC METHODS TO ALIMENTATION.

BUTCHER'S meat, which forms the basis of alimentation, is, along with milk food and fish, certainly the most difficult food product to preserve in a proper hygienic condition as soon as the temperature rises, or a storm is imminent. In the latter case, every one knows how anxious the housewife becomes lest her meat shall "turn." What happens on a small scale with the consumer occurs on a large scale with the butcher, who may, in the space of a few hours, have a large proportion of his stock decompose and become unsalable.

We have here a serious trouble—a grave danger which must be combated, and it is for the arts and manufactures to furnish the means for remedying it. They can do this by the application of frigorific processes.

If, in fact, we observe what occurs in winter (at Paris, for example), we find that the meat exposed in the butcher's stall is perfectly preserved for several days, provided that the temperature be not too variable, and remains at about from +2° to +4° C., with a very dry air. Under such circumstances, meat can not only be preserved for a long time, but even improves in various respects. It becomes freed of the excess of water that it contains and is consequently rendered more nutritious. Moreover, after it is cooked it is tender and succulent, and thus presents all the qualities required by hygienists and connoisseurs.

What nature grants us so liberally for a few weeks in the winter must be reproduced artificially during the warm months; but this no longer offers any serious difficulty, owing to the present progress of the applied sciences. As an example of this, we shall give the cold storage establishment recently installed at Paris for Mr. V. Velly, one of the largest wholesale butchers of the capital, by the Raoul Pictet Process Company, from plans drawn by Engineer Phelps, the process used being Schroeder's.

This establishment, the details of which are given in the accompanying engravings, consists of a one story building divided into four distinct parts, to wit: boiler room, machinery room, cold room and sales room.

The Boiler Room.—This contains a semi-tubular boiler with all its accessories, occupying quite a limited space. A wide door gives access to it, and assures of an easy removal of the tubular portion of the boiler from the room in case of cleaning or repairs.

Machinery Room.—In this room, separated from the foregoing by a simple partition, is found the entire mechanical part designed for the production of cold by the Pictet company's processes. It comprises a horizontal motor connected directly with a compression pump, the sulphurous anhydride condenser, the refrigeratory, a rotary pump, the transmissions, etc. The compression pump communicates on the one hand with an apparatus called a refrigeratory, containing liquid sulphurous anhydride, and on another hand with the condenser. During its operation, this pump, which is a double-acting one, vaporizes, on the one hand, the sulphurous anhydride of the refrigeratory, thus producing an intense cold absorbed by an incongealable liquid with which the refrigerant vat is fitted, and on another hand compresses the vapor thus produced and forces it to the condenser, where it is liquefied under the action of a current of cold water, which absorbs the heat produced by compression. The liquid sulphurous anhydride is sent back to the refrigeratory in order to begin again the same cycle of operations.

Cold Room.—The cold room, which is 39 ft. in length, 21 in width and 10½ in height, is capable of containing 26,000 lb. of meat, and has to be kept at a temperature of from +2° to +4° C. It is the most delicate part of the structure. Its sides, which are 28 inches in total thickness, consist of a wall of millstone, 20 inches in thickness, and one of brick 4 inches in thickness, with an interspace 4 inches in width. The space between the two walls is filled in with waste cork, so as to secure a nearly perfect isolation of the internal and external wall. Light is admitted through three small bays looking toward the north and closed by three glazed sashes in such a way as to leave between each glass a cushion of air sufficient to prevent any loss of cold. The walls, up to about five feet, are covered with cement, so as to permit of their being washed. The floors are of asphalt, and slope toward a drain connected with the sewer, so as to carry off the water. The room is provided above with iron work for supporting the ceiling. Two ventilating chimneys, T, placed at one of the extremities of the room, assure of a renewal of the air. These chimneys, which rise above the roof, and are provided with registers in the interior accessible to the hand, are opened according to the needs of the service.

In order to prevent a loss of cold through the ceiling, the latter is constructed in the usual manner and then covered with a layer of cork waste six inches in thickness, over which is placed a four inch thick layer of iron dross, which in turn is covered with a four inch layer of iron dross beton, and, finally, over all is spread a layer of asphalt or bitumen.

The part situated above the cold room, throughout the whole extent of the latter, and for a width of ten feet, is arranged with a view to the reception of the refrigerating apparatus, which consists of a series of tubes through which circulates the incongealable liquid brought to a mean temperature of —10° C., and forced by a rotary pump. On account of the extent of this system of tubes, having but one and the same circuit, it is divided into two groups, as shown in the transverse section. Owing to this arrangement, quite a sufficient space is left for the inspection of all the tubes, which are thus rendered accessible throughout their entire extent, so that the joints may be easily examined and repaired in case a leakage should be revealed. This tubular system, which is a true reservoir of cold, is itself perfectly isolated from the external air by double walls formed of jointed boards, and between which a 10 inch space is left that is filled in with waste cork. The ceiling also is formed of jointed boards upon which is deposited a layer of waste cork 20 inches in thickness.

The cold air enters the entrepot, properly so called, in the following way: The series of tubes, lowered to a temperature of —10° C., rapidly cools the surrounding air, and the latter, upon cooling, acquires a density that permits it to descend to the cold room through five central flues, F, running through the ceiling. This cools the room and the meat contained therein, while the warm air ascends through flues, C, placed laterally along the walls of the refrigerating chamber. This air traverses the tubes, becomes cold therein, and, freed from humidity, descends anew into the cold room. This circulation offers the great advantage of taking place slowly, and this consequently assures of the slow progressive cooling of the meat, the currents so prejudicial to its preservation being avoided, and the air being thoroughly dried.

Sales Room.—This part of the establishment succeeds the cold room, and receives the quarters of meat designed for the retail trade. It communicates with the cold room through the intermedium of a wooden air lock of sufficient size to allow a man carrying the largest piece of meat to enter, close the door behind him, and enter the cold room only after closing the first door. The door leading to the entrepot is formed of a double frame, whose interspace is filled in with cork waste. The isolation of the cold chamber is thus assured of on every hand, and the temperature of the lock is intermediate between that of the exterior and that of the frigorific entrepot.

We shall complete this rapid *expose* by saying that as the Velly establishment is designed to preserve 26,000 lb. of meat, with a mean reception and output of 6,600 lb. per day, from twelve to fourteen hours' operation suffices to secure a uniform temperature during the greatest heat. So all the humidity of the air and meat, which deposits upon the system of tubes in the form of hoar frost, is gotten rid of after the stoppage. This frost, in fact, thaws and falls in the form of water into gutters placed under the tubes, and is carried to the exterior by a special conduit. The floor of the refrigerating chamber is inclined sufficiently to allow of the flow of the water of condensation which may have fallen outside of the gutters.

However, it has been necessary to provide for the case in which, during an operation of several days in succession without stoppage, the frost has to be got rid of quickly. In this particular case, the end is obtained by means of a special arrangement that permits, through the maneuver of two cocks, of thawing the frost and of getting rid of the water within ten minutes' time. This precaution presents a great interest, for, when the tubes are covered with too thick a layer of ice, the transmission of heat through the sides is greatly reduced, as may be easily seen by comparing the temperatures upon the entrance of the refrigerant liquid into the tubes and upon its exit after a journey which, in the present case, exceeds 1,900 ft.

Although but very recently established, this entrepot has already rendered great services to the butchery business. Of this we shall give but the following example: One of the rare hot days that we have experienced this summer coincided with heavy arrivals of slaughtered sheep. By reason of the adverse temperature, this meat found no takers in our market, even at the low price of five cents a pound, and a very large quantity had to be thrown away.

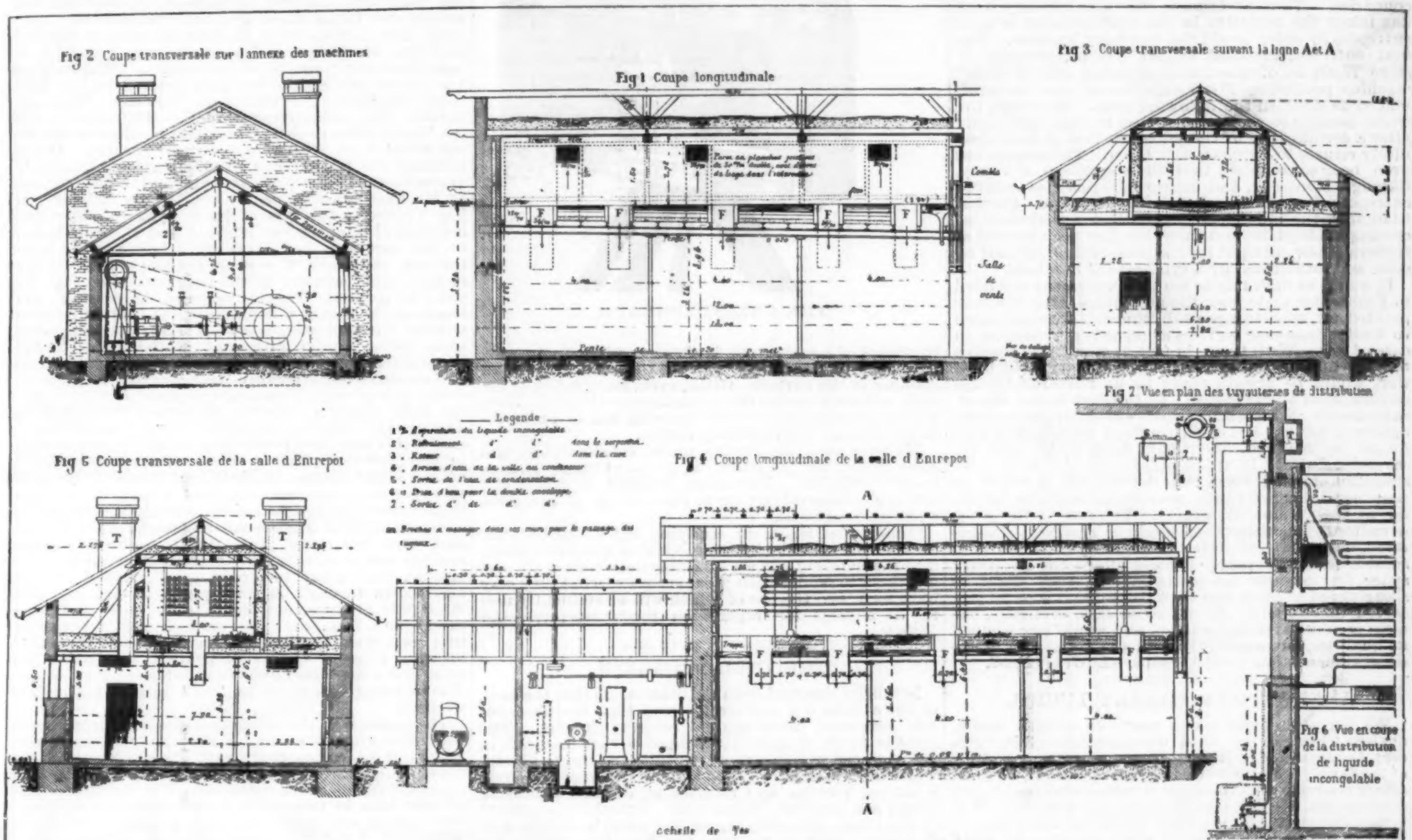


FIG. 1.—Longitudinal Section of Cold Room. FIG. 2.—Transverse Section of the Machine Room. FIG. 3.—Transverse Section on the line A A. FIG. 4.—Longitudinal Section of the Boiler, Machinery, and Cold Rooms. FIG. 5.—Transverse Section of Cold Room. FIG. 6.—Sectional View of the distribution of the Incongealable Liquid. FIG. 7.—Plan View of the Distributing Piping.

VELLY'S COLD STORAGE ESTABLISHMENT AT PARIS. (SCALE 1-80.)

A few butchers, who were better advised, then sent to the Velly entrepot some 30,000 lb. of this meat, which was thus prevented from decaying, and was sold three days afterward at the regular price of sixteen cents a pound.

It will be seen from this that cold storage establishments for the preservation of meat may reconcile the interests of both the seller and buyer by acting as regulators of the market. So we have the right to ask how it is that a city like Paris has not sooner understood the advantage of such establishments, and has not annexed them to its magnificent abattoirs. Such delay, it seems to us, must be attributed to the manner in which the butchery business of Paris is organized.

The butchers here are divided into two categories—the retailers, whose shops may be seen on every street, and the wholesalers, who alone kill the cattle. The latter they buy on foot twice a week, Monday and Thursday, at the Villette market. They daily slaughter what they suppose they can sell, while the rest of their purchase remains in the stalls, stables or pens arranged in the slaughter houses, their purchase and slaughtering being regulated according to the exigences of their sales and the temperature.

The meat is exposed in the butchery, which, upon the whole, is merely the wholesale store to which, after noon generally, the retailers repair every day to obtain their stock. Although the retailers can buy large pieces only, they can almost always make arrangements to take only what is strictly necessary for the day; and if the weather is unfavorable, several can combine to purchase a large piece and afterward divide it up among them according to agreement.

It results from these special arrangements of the Parisian market that the retail butcher has no need to be particularly solicitous about the preservation of the meat on his stand, seeing that he is always certain of finding fresh stock at the abattoirs at any time of the day. The cold storage establishment would be truly useful to the wholesale market only, but the latter, habituated for a long time to a definite way of doing things, hesitates to abandon it, although, in our opinion, it might find in the preservation of meat by cold a valuable aid in the regulation of both selling and purchase prices.

But the case is entirely different in the country, where the wholesale butcher does not exist, and where the retail butcher buys the animal on foot and slaughters it and retails the meat. The markets there are not so frequent—once per week at the most—and this obliges the butcher to stable his cattle, which cost him dearly to feed, and which, far from gaining in quality, depreciate quite rapidly. If a high temperature suddenly supervenes, and the sale of the meat becomes more precarious, the country butcher kills nothing but small cattle; and so we often find cities, even of some size, in which it is impossible to procure beef or veal on certain days of the week. This state of things would no longer be the same with a cold storage entrepot. The butcher could then slaughter on the same day all the cattle purchased and send it to the entrepot and withdraw it therefrom in measure as he needed it, and even in very small quantities. As for the additional cost that would be added to his meat by reason of the rental of a certain space in the entrepot, that would be much less than that due to the expense of feeding living cattle.

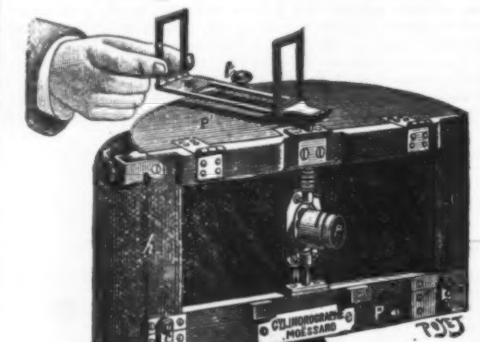
It is these advantages as a whole that have caused cold storage establishments to be adopted in foreign countries. Thus, at Geneva, the municipality itself has taken the initiative in the establishment of such entrepots in order to aid the butchery business. The first entrepot, installed by Mr. Phelps, designed to store 77,000 lb. of meat, and provided with a Pictet machine producing 25,000 negative calories per hour, had to be doubled the following year. Moreover, the trade became so soon accustomed to take meat only after a certain stay in the entrepot, that it now absolutely refuses to purchase any other. The success has even been so complete that the communes of Vevay, Caronge, Montreux, and others have likewise installed entrepots after the model of those of Geneva. Further than this, the municipal installations are already becoming inadequate, and there has just been opened at Geneva a new entrepot for the preservation of meat by cold, and established by a syndicate of butchers.

It would be desirable to see this movement extended in France, for aside from the advantages that we have pointed out, cold storage establishments are called upon to render immense services as regards provisioning in case of war. With them, in fact, it would be possible to store up in certain centers large quantities of meat that would be always ready to be delivered for the consumption of our troops. In fortified towns, the arrangements to be made would evidently be entirely different, in that the cattle confined therein would no longer be renewed, and would have to be kept for several months. In this special case, the daily consumption having once been determined, it would be possible to slaughter and preserve some of the beasts, for at least a month's supply. The rest, if the place permitted of stabling them, might be gradually slaughtered, every day, in order to replace the meat consumed, or, if the place did not afford the necessary space for keeping the cattle on foot, they might be slaughtered at once, and then frozen, and thus be preserved indefinitely. In the latter case, evidently, the meat would be less appreciated and would lose some of its qualities, but would still form a rational and wholesome alimentation for the troops.—*Le Genie Civil.*

A NEW FIELD CAMERA LUCIDA.

We herewith figure a new portable camera lucida, devised by one of our most distinguished cavalry officers, Commander H. Blain. This apparatus is capable of rendering great services to the amateur, or to an officer charged with the duty of reconnoitering during a campaign. As General De Brack has well said: "It is as indispensable to a cavalry officer to know how to draw as it is to know how to write, because he often says more and says it better with two lines than with two written pages, and because a few strokes of the pencil are made more quickly and easily than a report can be composed, and they guarantee and class the details of such report better than does the recollection that is preserved of a long reconnaissance. . . . The habitude of drawing gives the memory a faculty that might be called instinctive; it is that of seizing, so to speak, in spite of ourselves and without being distracted by other thoughts, the form and color of the objects that present themselves before us. It offers one immense advantage for war, and that is that it habituates a person to keep his eyes open and observe well, to estimate distances, and note the nature of the ground, to bring before him what he has seen, and especially to judge of the possibility of the rapidity and appositeness of enterprises."

A camera that facilitates the execution of sketches to the highest degree cannot be too highly recommended to amateurs and officers, since it suffices to trace in a manner the image obtained. Commander Blain's new apparatus is essentially portable when it is folded up, and can be easily carried by a cavalryman. It consists of a small 12×16 in. table provided with three automatic legs, which pull out as shown in Fig. 1. The camera, properly so called, is mounted above the table, with an opaque curtain of a black material. After the table has been raised as high as the rods will allow it to go, it is gradually lowered until the image projected on a sheet of white paper on the table has acquired the requisite sharpness. The system is fixed



THE CYLINDROGRAPH.

by means of a screw. It is then possible to draw or paint on the paper upon putting the head through an opening in the curtain. Often, even, the shadow of the body suffices to make the image appear (Fig. 2). With a little practice, water color drawing can be made directly without a preliminary sketch.

We have used the camera under consideration, and have found that the reflecting power of the apparatus is quite sufficient. The image obtained is sharp, and not at all distorted, owing to the quality of the glass and rectilinear lens.

Commander Blain, in studying out his apparatus, has had the special object in view of quickly putting into the hands of officers infallible data that shall permit them to render with great accuracy what they may have seen, and the use of which will be eminently useful as a basis for reports on reconnaissances.—*La Nature.*

THE CYLINDROGRAPH.

It will be observed from the illustration that the back of the camera is a half circle, to which a flexible celluloid sensitized plate can be readily attached. The front is made of loose light-proof woven material, in the center of which a rapid rectilinear lens is placed. This lens is fixed to an interior body, which is merely a narrow section, and receives at the end a focusing screen less than two inches wide. Exactly this amount of the image is thrown upon the sensitized plate, and it follows that, if we turn the lens by moving the handle from one side of the front to the other (as shown in the illustration), we shall throw upon the plate nearly one-half of the horizon, and so obtain a truly panoramic view, with a trueness of continuity such as could not be obtained before. For instance, the other day Mr. Houghton took the camera to the south side of the Thames and placed it on the embankment in front of St. Thomas' Hospital. There he took a picture, which included Westminster Bridge on the east, the Houses of Parliament in front, and the greater part of Lambeth Bridge on the west. Some beautiful photos of the Paris exhibition our man saw—one of the machinery gallery giving a better idea of that gigantic building than it was possible to imagine that a photograph could give. The pictures are, of course, at their truest and best when bent to the form that the negative had when taken; but even when flat they show not a bit of distortion.—*Chem. and Druggist.*

THE TELPHER RAILWAY.

The telpher railway, which is the most prominent and interesting feature of the Edinburgh exhibition, is thus described by *The Engineer*, to which we are indebted for our illustrations.

By way of rendering the plant more attractive to visitors and assisting in defraying the expenses, the cars have been built to convey passengers, although it is not to be supposed that this would be its more special practical application. The telpher line at Glynde, near Brighton, was in use for the transport of clay from the quarry to the nearest point on the main line of railway, a distance of over a mile; and there are many districts—as pointed out by the late Professor Fleeming Jenkin, the originator of the system—where, in the conveyance of goods and raw material from working centers to the railway for transport, the cost and working expenses of a telpher line ought to be considerably less than conveyance by cartage. In mountainous districts also the telpher line can, it is claimed, be made to cross rivers and valleys and follow steep gradients without the enormous first cost incurred in such districts in the construction of bridges and viaducts strong enough to bear the heavy tonnage of locomotives. The telpher line in the exhibition has been erected by the Electrical Engineering Corporation, Limited. This corporation is an amalgamation of J. G. Statter & Co. and the United Electrical Engineering Co., their works being situated at West Drayton, near London. Before noticing the telpher line in detail, attention may be drawn to the types of dynamo and motor brought out by Mr. Statter and in use on the telpher railway. In Fig. 1 is shown the type of 2-pole dynamo. The field is of forged iron, the two limbs, A and B, being bolted to the cast iron bed plate by a bolt passing right through the block, C, cast on the bed plate. By this means a good contact in the magnetic circuit at the yoke is secured. For convenience in forging, and lessening the cost of manufacture, the limbs are forged without the projecting horns, H H, of the pole pieces, these being put on afterward in the shape of small rectangular pieces fixed by studs screwed in the limb and riveted over, afterward being bored out with the entire pole piece. A gun metal guard is fixed across the pole pieces at the top to protect the armature. The dynamo supplying current to the telpher line is one of this type, compound wound, and is driven within the machinery hall at the stand of the corporation by a vertical engine of their own make. The armatures are cylindrical and Gramme wound; a practical improvement being effected by dividing the thin plates of which the core is made into three segments, that is, each thin iron built plate ring is in three divisions, and the core is therefore in three distinct parts interlapping each other to form a good magnetic circuit, and bolted through in three places to each segment. With this arrangement the coils can be wound separately on a form, and afterward slipped on the armature core, the operation, although still done by hand, insuring a better chance of properly insulating the coils, and a more easy division of labor in manufacture. The winding is known as Joel's sectional armature winding.

The motor is of the same construction as regards the field; the armature core, however, is not segmental, but built of entire rings with Paccinotti teeth, between which the coils are wound. We illustrate also another type of Statter dynamo—Fig. 2—with a field of cast iron in two parts, bolted together as shown. This type is only made for small dynamos, where the lower cost of cast iron compensates for less permeability. We shall refer again to these machines when treating of the electric tramway. The telpher line erected in the exhibition grounds forms one complete circuit, the straight portion of the lines covering a distance of 360 ft., and the curves at either end having a radius of 40 ft.

The distance from one point to the same point again is exactly 440 yards, and this is performed by the cars in two and one-half minutes, making, therefore, a speed of six miles per hour. Three cars are drawn by the motor, each of which seats four persons. Referring to Figs. 3 and 5, the manner of supporting the rigid portion of the line will be seen to be by cast iron brackets, B B, bolted to the outside of the post, and wrought iron plates, P P, bolted to the inside and the upper end of the brackets. The line is only rigid on the curved portions, part of one of these curves being shown in Fig. 3. It will be seen in this figure that the insulators supporting the electric conductor are bolted to the iron plates, also that the car is hung by two iron bars, M M, each of which is supported by a pair of wheels on the track. These suspension bars are jointed above at H H, where they rest on the springs carried by the wheels, and below on the cars at T T, so that when the slight upward and downward gradient occurs on nearing and leaving a post respectively, the car is perfectly free to take up a true vertical position, and only its dead weight acts on the supports, which are, therefore, not strained.

The straight portion of the track is of steel wire rope, each end of which is shackled off to a straining post, as shown in Fig. 4. The joint between the rigid rail and steel wire rope portions of the track is effected by passing the wire rope through a special form of cast iron shoe, A—Fig. 4—bolted to the bracket on the post. The wire rope fits in a tapered hollow groove in the shoe, and is bolted down by a cap, C, which firmly grips it. At the same time the rigid rail is sloped down to the wire rope by a wedge shape piece of rail, R, bolted on as shown.

The going and returning track on the straight portion of the line are mounted on one post, as shown in

Fig. 1.—PORTABLE CAMERA LUCIDA—ARRANGEMENT OF THE APPARATUS.

Fig. 2.—METHOD OF USING THE APPARATUS.

Fig. 7. Here the steel wire ropes are carried at the extreme ends of the brackets fastened down in cast iron shoes at SS. One of these shoes is shown in Fig. 6.

The motor and its connections are shown in Fig. 8. A pinion on the motor axle gears first into a large helicoidal wheel, on the spindle of which a small pitch chain wheel is fixed. The pitch chain operates the axle above, again reducing the speed. From this axle, shown at the center in Fig. 10, the motion is again communicated by pitch chain gearing to the two driving wheels, as shown.

The method of effecting continuous contact between the motor and the iron wire rope conductor may now be considered. This is of special interest in the fact that just now at the time of writing a considerable improvement has been effected. This consists in the manner of collecting the current, and has been introduced by Mr. John Cushny, the engineer to the corporation, to whom we are indebted for particulars of the telpherage system. The *raison d'être* for this change will be best understood by reference to the method adopted up to the present. The system being a parallel one, the necessity only exists for one insulated conductor round the whole track in connection with one pole of the generating machine, the return being to the rail. This conductor is of iron wire rope, and was strained somewhat tightly over grooved carriers fixed above the insulators, as shown in the engravings. The contact wheel, which makes good electrical connection with one pole of the motor, was mounted at the end of a double jointed and counterbalanced arm, as shown in Fig. 9. The contact, therefore, depended upon the rigidity of the conductor and

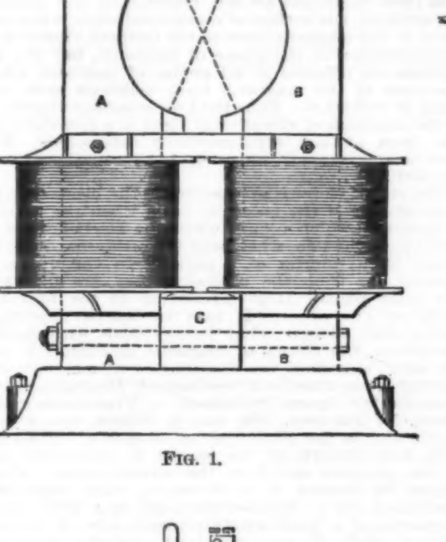


FIG. 1.

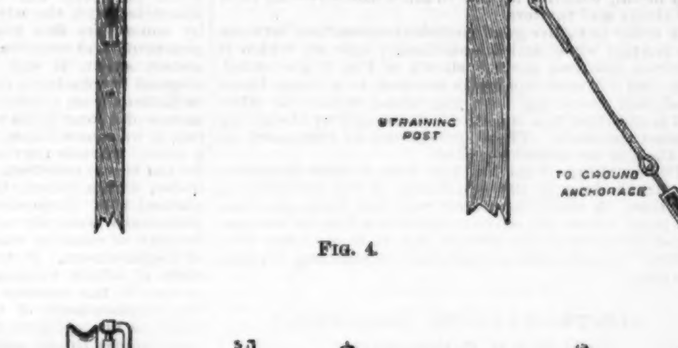


FIG. 4.

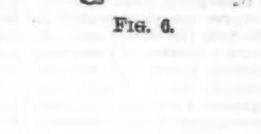


FIG. 6.

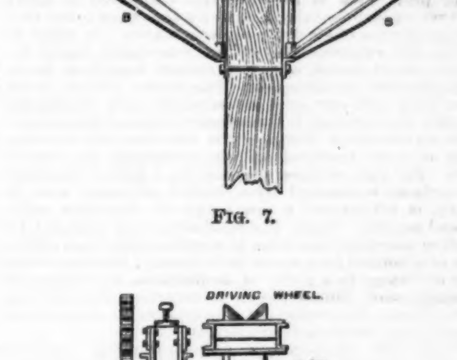


FIG. 7.

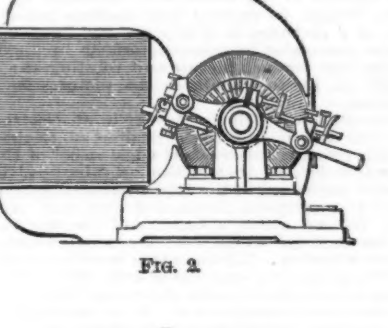


FIG. 2.

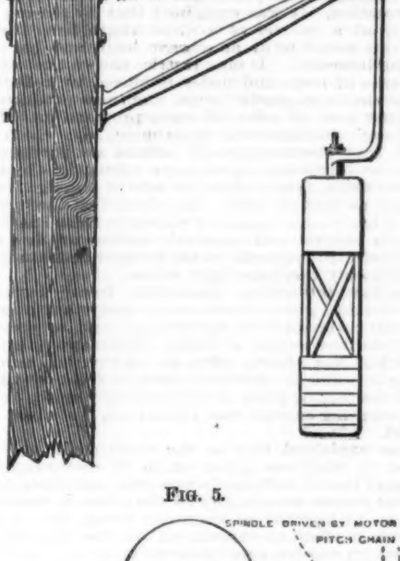


FIG. 5.

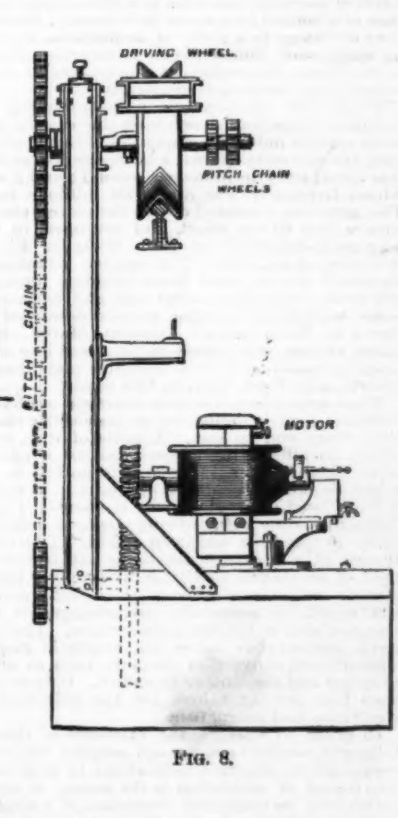


FIG. 8.

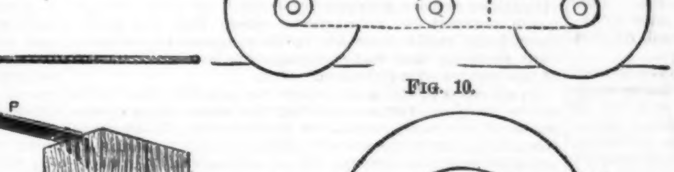


FIG. 10.

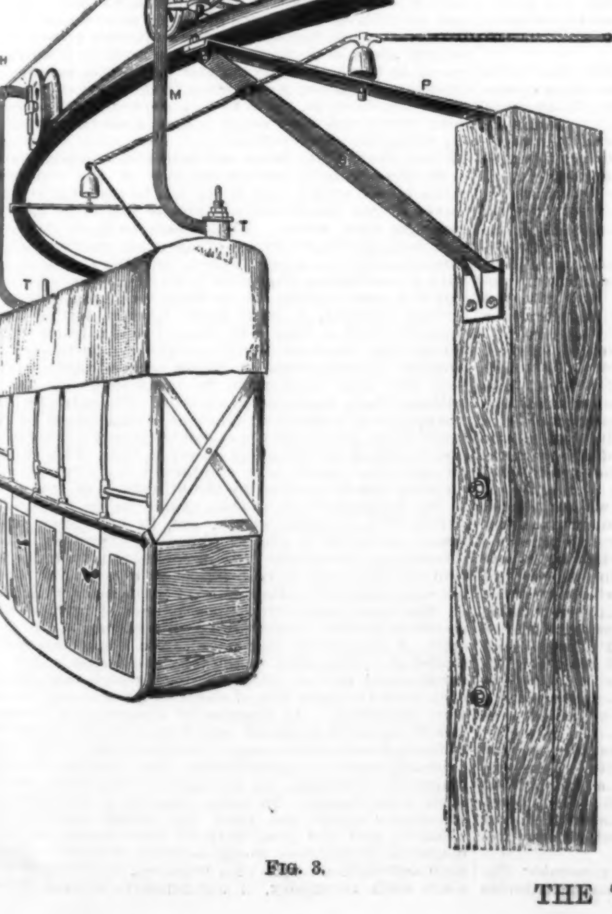


FIG. 3.

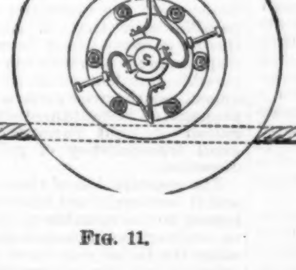


FIG. 11.

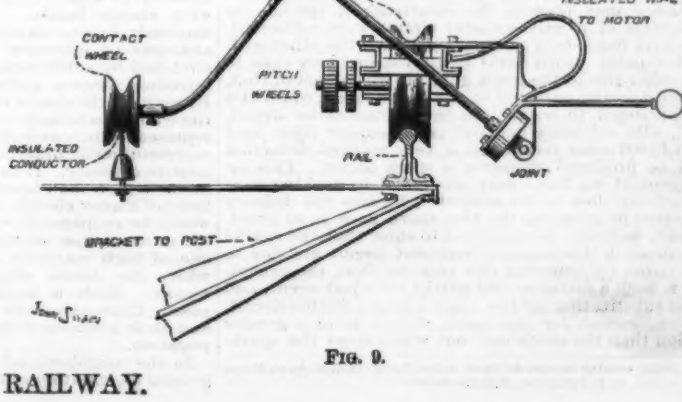


FIG. 9.

THE TELPHER RAILWAY.

the downward pressure of the wheel, but these two factors were the cause of an undue strain upon the insulators, resulting in several fractures. The improvement consists in suspending the wire rope slack, and running the contact wheel underneath instead of over it, in which case there is absolutely no strain on the insulators. To effect this the carrier on each insulator is turned round through a right angle, and instead of fixing the wire rope on to it, a short length of ½ in. iron rod is affixed thereto in the same manner. The wire rope conductor then simply rests on the rod, the latter being bent up at the end to prevent the wire rope slipping off. As the wheel passes it lifts the conductor off the rod, and allows it to fall back again into position after passing.

The insulators are of American manufacture, of compressed mica and shellac, according to the Lehte patent. These insulators are bushed at both ends with gun metal, which is tapped to allow the screwing in of the stalks and carriers.

In order to insure good electrical connection between the contact wheel and the stationary axle on which it revolves, the two springs shown in Fig. 11 are added. One end of each spring is screwed to a brass block fixed and revolving with the wheel, while the other end is attached to a similar block pressed by the spring against the shaft. These springs can be tightened up by the side set screws as shown.

The working of the line has been further improved by Mr. Cushny in the equalizing of the potential on the line. A small insulated wire has been run from the point where the current enters the line to the center of the curve at the distant end, so doing away with "drop" of potential and generally equalizing it along the line.

ELECTRO-MAGNETIC RADIATION.*

By Prof. G. F. FITZGERALD.

IN order to discover whether actions are propagated in time or instantaneously, we may employ the principle of interference to measure the wave length of a periodic disturbance, and determine whether it is finite or not. This is the principle employed by Hertz to prove experimentally Maxwell's theory as to the rate of propagation of electro-magnetic waves. In order to confine the experiments within reasonable limits we require short waves, of a few meters length at most. As the highest audible note gives waves of five or six miles long, and our eyes are sensitive only to unmanageably short waves, it is necessary to generate and observe waves whose frequency is intermediate between them, of some hundred million vibrations per second or so. For this purpose we may use a pair of conducting surfaces connected by a shorter or longer wire, in which, is interposed a spark gap of some few millimeters' length. When the conductors are charged by a coil or electrical machine to a sufficiently high difference of potential for a spark to be formed between them they discharge in a series of oscillations, whose period for systems of similar shape is inversely proportional to the linear dimensions of the system as long as the surrounding medium is unaltered.

When the surrounding non-conducting medium changes, the period depends on the electric and magnetic specific inductive capacities of this medium. Two such systems were shown: a large one, whose frequency was about sixty millions per second; and a small one, whose frequency was about 500 millions per second. The large one consisted of two flat plates, about 30 cm. square and 60 cm. apart, and arranged in the same way as is described by Prof. Hertz in *Wiedemann's Annalen*, April, 1888. The smaller vibrating system consisted of two short brass cylinders terminating in gilt brass balls of the same size, and arranged in the same way as the smaller system described by Prof. Hertz in *Wiedemann's Annalen*, March, 1889. This latter system was placed in the focal line of a cylindrical parabolic mirror of thin zinc plate, such as that described by Prof. Hertz in this paper.

These generators of electro-magnetic oscillations may be called electric oscillators, as the electric charge oscillates from end to end. A circle of wire, or a coil in which an alternating current ran, or, if such a thing were attainable, a magnet alternating in polarity, might be called a magnetic oscillator. A ring magnet with a closed magnetic circuit is essentially an electric oscillator, while a ring of ring magnets would be essentially a magnetic oscillator again. The elementary theory of a magnetic oscillator can be derived from that of an electric oscillator by simply interchanging electric and magnetic force. Electricity and magnetism would be essentially interchangeable if such a thing existed as magnetic conduction. The only magnetic currents we know are magnetic displacement currents and convection currents, such as are used in unipolar and some other dynamos. It is in this difference that we must look for the difference between electricity and magnetism.

In order to observe the existence of these electromagnetic oscillations, we can employ the principle of resonance to generate oscillations in a system whose free period of oscillation is the same. A magnetic receiver may be employed, consisting of a single incomplete circle of wire broken by a very minute spark gap, across which a spark leaps when the oscillations in the wire become sufficiently intense. In order that a large audience may observe the occurrence of sparks, the terminals of a galvanometer circuit were connected, one with one side of the spark gap, and the other with a fine point which could be approached very close to the other side of the spark gap. It was observed that, when a spark occurred in the gap, a spark could also be arranged to occur into the galvanometer circuit, and, with a delicate long coil galvanometer (that used had 40,000 ohms resistance), a very marked deflection can be produced whenever a spark occurs. This arrangement we have only succeeded in working comparatively close to the generator, because the delicacy required in adjusting the two spark gaps is so great. It can, however, be employed to show that the sparks produced in this magnetic resonant circuit are due to resonance by removing this receiver from the generator to such a distance that sparks only just occur, and then substituting for the single circuit a double circuit, which, except for resonance, should have a greater action than the single one, but which stops the sparking altogether. An electric receiver was also used, which was identical with the generator, and had a corresponding, only much smaller, spark gap between the two plates. When the plates are connected with the terminals of the galvanometer, upon the occurrence of each spark the galvanometer is deflected. It is not so easy to obtain sparks when the plates are connected with the galvanometer as when they are insulated, and it is this that has limited the use of this method of observation. By making the first meter or so of the wires to the galvanometer of extremely fine wire, so as to reduce their capacity, we have found that the difficulty of getting sparks is less than with thick wires. We have not observed any effect due to the thickness of the wires after a short distance from the receiver.

In the case of the small oscillator, a receiver exactly like the one described by Prof. Hertz in his second paper already quoted was placed in the focal line of a cylindrical parabolic mirror, and its receiving wires were connected with the wires leading to the galvanometer by some very fine brass wire. With the large sized generator and receiver, which were placed about three meters apart, it was shown that the sparking was stopped by placing a thin zinc sheet so as to reflect the radiations from a point close behind the receiver. By means of a long India rubber tube hung from the ceiling, it was shown how, when waves are propagated to a point whence they are reflected, the direct and reflected waves interfering produce a system of loops and nodes, with a node at the reflecting point. It was explained that these nodes, though places of zero displacement, were places of maximum rotation, and that the axis of rotation was at right angles to the direction of displacement. It was explained that an analogous state of affairs existed in the electro-magnetic vibrations. If the electric force be taken as analogous to the displacement of the rope, the magnetic may be taken as analogous to its rotation, and the two are at right angles to one another. In the ether the electric node is a magnetic loop, and *vice versa*. Though the two are separated in loops and nodes, they exist simultaneously in a simple wave propagation, just as in a rope when propagating waves in one direction the crest of maximum displacement is also that of maximum rotation. It was explained that by placing the reflector at a quarter of a wave length from the receiver this would be at an electric loop, and have its sparking increased. It may thus be shown that there are a series of loops and nodes produced by reflection of these electro-magnetic forces, like those produced in any other case of reflected wave propagation. This was Hertz's fundamental experiment, by which he proved that electro-magnetic actions are propagated in time, and by some approximate calculations he verified Maxwell's theory that the rate of propagation is the same as that of light. It follows that the luminiferous ether is experimentally shown to be the medium to which electric and magnetic actions are due, and that the electro-magnetic waves we have been studying are really only very long light waves.

A rather interesting deduction from Maxwell's theory is that light incident on any body that absorbs or reflects it should press upon it and tend to move it away from the source of light. Illustrating this, an experiment was shown with an alternating current passing through an electro-magnet, in front of which a good conducting plate of silver was suspended. When the alternating current was turned on, the silver was repelled.

It was explained that as the silver could only be affected by what was going on in its own neighborhood, and that if sufficiently powerful radiations from a distant source were falling on the silver, it would be acted on by alternating magnetic forces, this experiment was in effect an experiment on the repulsion of light, which was too small to have been yet observed, even in the case of concentrated sunshine. These slow vibrations are not stopped by a sheet of zinc, though much reduced by a magnetic sheet like tin plate, though the rapid ones are quite stopped by either—thus showing that wave propagation in a conductor is of the nature of a diffusion.

In all cases of diffusion where we consider the limits of the problem, terms involving the momentum of the parts of the body must be introduced. It appears from elementary theories of diffusion as if it were propagated instantaneously, but no action can be propagated from molecule to molecule, in air, for instance, faster than the molecules move, *i. e.*, at a rate comparable with that of sound. In electro-magnetic theory corresponding terms come in by introducing displacement currents in conductors, and it seems impossible but that some such terms should be introduced, as otherwise electro-magnetic action would be propagated instantaneously in conductors. The propagation of light through electrolytes, and the too great transparency of gold leaf, point in the same direction.

The constitution of these waves was then considered, and it was explained that if magnetic forces are analogous to the rotation of the elements of a wave, then an ordinary solid cannot be analogous to the ether, because the latter may have a constant magnetic force existing in it for any length of time, while an elastic solid cannot have continuous rotation of its elements in one direction existing within it. The most satisfactory model, with properties quite analogous to those of the ether, is one consisting of wheels geared with elastic bands. The wheels can rotate continuously in one direction, and their rotation is the analogue of magnetic force. The elastic bands are stretched by a difference of rotation of the wheels and introduce stresses quite analogous to electric forces. By making the elastic bands of lines of governor balls, the whole model may have only kinetic energy, and so represent a fundamental theory. Such a model can represent media differing in electric and magnetic inductive capacity. If the elasticity of the bands be less in one region than another, such a region represents a body of higher electric inductive capacity, and waves would be propagated more slowly in it. A region in which the masses of the wheels were large would be one of high magnetic inductive capacity. A region where the bands slipped would be a conducting region. Such a model, unlike most others proposed, illustrates both electric and magnetic forces and their inter-relations, and consequently light propagation.

In the neighborhood of an electric generator the general distribution of the electric and magnetic forces is easily seen. The electric lines of force must lie in planes passing through the axis of the generator, while the lines of magnetic force lie in circles round this axis and perpendicular to the lines of electric force.

It is thus evident that the wave is, at least originally, polarized. To show this, the small sized oscillators with parabolic mirrors were used, and a light square frame, on which wires parallel to one direction were strung, was interposed between the mirrors. It was shown that such a system of wires was opaque to the radiation when the wires were parallel to the electric force, but was quite transparent when the frame was turned so that the wires were parallel to the magnetic force. It behaved just like a tourmaline to polarized light. It is of great interest to verify experimentally Maxwell's theory that the plane of polarization of light is the plane of the magnetic force. This has been done by Mr. Trouton, who has shown that these radiations are not reflected at the polarizing angle by the surface of a non-conductor, when the plane of the magnetic force in the incident vibration is perpendicular to the plane of incidence, but the radiations are reflected at all angles of incidence when the plane of the magnetic force coincides with the plane of incidence. Thus the long-standing dispute as to the direction of vibration of light in a polarized ray has been at last experimentally determined. The electric and magnetic forces are not simultaneous near the oscillator.

The electric force is greatest when the electrification is greatest, and the magnetic force when the current is greatest, which occurs when the electrification is zero; thus the two, when near the oscillator, differ in phase by a quarter of a period. In the waves, as existing far from the oscillator, they are always in the same phase. It is interesting to see how one gains on the other. It may be worth observing, again, that though what follows deals with electric oscillators, the theory of magnetic oscillators is just the same, only that the distribution of magnetic and electric forces must be interchanged. Diagrams drawn from Hertz's figures published in *Wiedemann's Annalen* for January, 1889, and in *Nature*, vol. xxxix., p. 451, and in the *Philosophical Magazine* for March, 1890, were thrown on the screen in succession, and it was pointed out how the electric wave, which might be likened to a diverging whirl ring, was generated, not at the oscillator, but at a point about a quarter of a wave length on each side of the oscillator, while it was explained that the magnetic force wave starts from the oscillator. It thus appears how one gains the quarter period on the other.

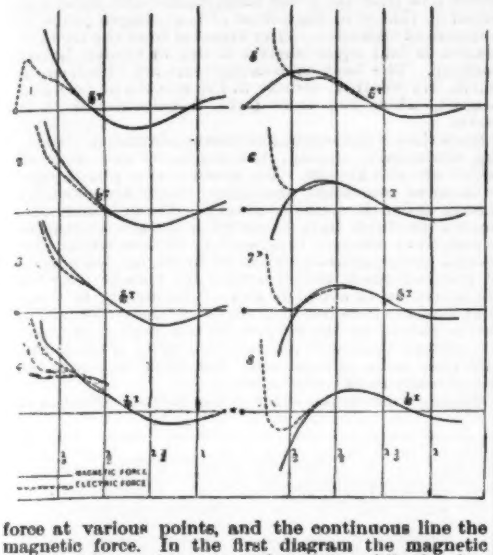
The outflow of the waves was exhibited by causing the images to succeed one another rapidly by means of a zoetrope, in which all the light is used and the succession of images formed by having a separate lens for each picture and rotating the beam of light so as to illuminate the pictures in rapid succession.

As the direction of flow of energy in an electro-magnetic field depends on the directions of electric and magnetic force, being reversed when either of these is reversed, it follows that in the neighborhood of the oscillator the energy of the field alternates between the electric and magnetic forms, and that it is only the energy beyond about a quarter of the wave length from the oscillator which is wholly radiated away during each vibration. It follows that in ordinary electro-magnetic alternating currents at from 100 to 200 alternations per second, it is only the energy which is some 3,000 miles away which is lost. If an electro-magnetic wave, having magnetic force comparable to that near an ordinary electro-magnet, were producible, the power of the radiation would be stupendous. If we consider the possible radiating power of an atom by calculating it upon the hypothesis that the atomic charge oscillates across the diameter of the atom, we find that it may be millions of millions of times as great as Prof. Wiedemann has found to be the radiating power of a sodium atom in a Bunsen burner, so that, if there is reason to think that any greater oscillation might disintegrate the atom, it is evident that we are still a long way from doing so. It is to be observed that ordinary light waves are very much longer than the period of the vibration above referred to. Dr. Lodge has pointed out that quite large oscillators in comparison to molecules—namely, about the size of the rods and cones in the retina—are of the size to resound to light waves of the length we see, and so might be used to generate such waves. This seems to show that the electro-magnetic structure of an atom must be more complicated than a small sphere or other simple shape with an oscillating charge on it, for the period of vibration of a small system can be made long by making the system complex, *e. g.*, a small Leyden jar of large capacity with a long wire wound many times round connecting its coats, could easily be constructed to produce electro-magnetic waves whose length would bear the same proportion to the size of the jar as ordinary light waves do to an atom. The rate at which the energy of a Hertzian vibrator is transferred to the ether is so great that we would expect an atom to possess the great radiating power it has. This shows, on the other hand, how completely the vibrations of an atom must be forced by the vibrations of the ether in its neighborhood, so that atoms, being close compared with a wave length, are, in any given small space, probably in similar phases of vibration. It is interesting to consider this in connection with the action of molecules in collision as to how far the forces between molecules after collision is the same as before. In the same connection the existence of intra-atomic electro-magnetic oscillations is interesting in the theories of anomalous dispersion. An electro-magnetic model of a prism with anomalous dispersion might be constructed out of pitch, through which conductors, each with the same rate of electro-magnetic oscillation, were dispersed. In theories of dispersion a dissipation of energy is assumed, and it may be the radiation of the induced electro-magnetic vibrations. These can evidently never be greater than the incident electro-magnetic vibration, on account of this radiation of their own energy. In some theories a vibration of something much less than the whole molecule is assumed, and the possibility of intra-atomic electro-magnetic oscillations would account for this. Some such assumption seems also required, in order to explain such secondary, if not tertiary, actions as the

* Friday evening lecture delivered at the Royal Institution on March 21, by Prof. G. F. Fitzgerald, F.R.S.—*Nature.*

Hall effect and the rotation of the plane of polarization of light, which are, apparently at least, secondary actions due to a reaction of the matter set in motion by the radiation on this radiation.

Some further diagrams were exhibited, plotted from Hertz's theory by Mr. Trouton, to whom much of the matter in this paper is due. They are here reproduced, and show eight simultaneous positions of the electric and magnetic waves during a semi-oscillation of an electric oscillator. The dotted line shows the electric



force at various points, and the continuous line the magnetic force. In the first diagram the magnetic force is at its maximum near the origin, while the electric force there is zero. In the second the magnetic energy near the origin has partly turned into electric energy, and consequently electric force begins. The succeeding figures show how the magnetic force decreases near the origin, while the electric force grows, and the waves already thrown off spread away. The change of magnetic force between Figs. 4 and 5 is so rapid that a few dashed lines, showing interpolated positions, are introduced to show how it proceeds. It will be observed how a hollow comes in the line showing electric force, which gradually increases, and, crossing the line of zero force at about a quarter of a wave length from the origin, is the source of the electric wave, which, starting with this odds, picks up and remains thenceforward coincident with the magnetic wave. From this origin of electric waves they spread out along with the magnetic waves and in toward the origin, to be reproduced again from this point on the next vibration. These electric and magnetic forces here shown as coincident are, of course, in space in directions at right angles to one another, as already explained. The corresponding diagrams for a magnetic oscillator are got by interchanging the electric and magnetic forces.

A further experiment was shown to illustrate how waves of transverse vibration can be propagated along a straight hollow vortex in water. It was stated that what seemed a possible theory of ether and matter was that space was full of such infinite vortices in every direction, and that among them closed vortex rings represented matter threading its way through the ether. This hypothesis explains the differences in nature as differences of motion. If it be true, ether, matter, gold, air, wood, brains, are but different motions. Where alone we can know what motion in itself is—that is, in our own brains—we *know* nothing but thought. Can we resist the conclusion that all motion is thought? Not that contradiction in terms, unconscious thought, but living thought; that all nature is the language of One in whom we live, and move, and have our being.

A CONTRIBUTION TO THE ETIOLOGY OF DIPHTHERIA.*

By Dr. E. KLEIN.

THE microbe, which was first described by Klebs (at the Wiesbaden Congress in 1883), then isolated and grown in artificial cultures by Loffler (*Mitth. aus dem K. Gesundheitsamte*, vol. ii.) from human diphtheritic membrane, was shown by this observer to act virulently on various animals. The Klebs-Loffler bacillus—by which name the diphtheria microbe is known—is the one with which also Roux and Yersin (*Annales de l'Institut Pasteur*, ii., 1888, No. 12) obtained positive results on guinea pigs.

In the Reports of the Medical Officer of the Local Government Board for 1888-89 and 1889-90, I have shown that there occur in diphtheritic membranes two species of bacilli, very similar in morphological respects, and also in cultures on serum and on agar, but differing from one another in this, that one species, Klebs-Loffler bacillus No. 1, is not constant in diphtheritic membranes, does not grow on solid gelatine at 19°-20° C., and does not act pathogenically on animals; the other species, Klebs-Loffler bacillus No. 2, is constant in diphtheritic membranes, in fact is present even in the deeper layers of the membranes in great masses and almost in pure culture, acts very virulently on animals, and grows well on gelatine at 19°-20° C. Loffler, and after him other observers (Flugge, "Die Mikroorganismen," 1886), considered it as a character of the diphtheria bacillus that it does not grow on gelatine below 22° C., but this character, though true of the Klebs-Loffler species No. 1, does not appertain to the diphtheria bacillus species No. 2. In fact, there is no difficulty in obtaining pure cultures of this bacillus on gelatine if a particle of diphtheritic membrane be taken and well shaken in two or three successive lots of sterile salt solution, and from the last lot plate cultivations on gelatine are made. In this way I have obtained the diphtheria bacillus in great numbers of colonies and in pure culture. Zarniko (*Centralbl. f. Bakteriol. u. Parasit.*, vol. vi., 1889, p. 154) and Escherich (*ibid.*, vol. vii., 1890, p. 8) both state that the diphtheria bacillus does grow on gelatine below 20° C.

This bacillus diphtheriæ acts very virulently on guinea pigs on subcutaneous inoculation; at the seat of the injection a tumor is produced, which in its pathology and in microscopic sections completely resembles the diphtheritic tissue of the human. In human diphtheria the diphtheria bacillus is present only in the diphtheritic membrane, but neither in the blood nor in the diseased viscera; the same holds good for the experimental guinea pigs. In subcutaneous inoculation with artificial culture, though it causes in these animals acute disease and death—the lungs, intestines, and kidney are greatly congested—the diphtheria bacillus remains limited to the seat of inoculation. It was for these reasons that Loffler concluded that in diphtheria the diphtheritic membrane alone is the seat of the multiplication of the diphtheria bacillus, and that here a chemical poison is produced, which, absorbed into the system, causes the general diseased condition and eventually death. Roux and Yersin have then separated from artificial broth cultures the bacilli and the chemical products, and, by the injection of these latter alone into guinea pigs, have produced a general effect. I have in this year's Report to the Medical Officer of the Local Government Board (1889-90) shown that in these experiments of injection of cultures into guinea pigs, an active multiplication of the diphtheria bacilli at the seat of inoculation can be demonstrated by culture experiments; from the local diphtheritic tumor and the nearest lymph glands the diphtheria bacilli can be obtained in pure culture on gelatine.

On various occasions during the last three years information has reached me by health officers (Dr. Downes, Mr. Shirley Murphy, Dr. Thursfield) as to a curious relation existing between a mysterious cat disease and human diphtheria in this manner, that a cat or cats were taken ill with a pulmonary disease, and while ill were nursed by children, and then these latter sickened with well-marked diphtheria. Or children were taken ill with diphtheria, and either at the same time or afterward the cat or cats sickened. The disease in the cat was described as an acute lung trouble; the animals were quiet, did not feed, and seemed not to be able to swallow; in some cases they recovered, in others they became emaciated, while the lung trouble increased, and ultimately they died. In one instance—in the north of London, in the spring, 1889—this cat malady, occurring in a house where diphtheria soon afterward appeared among the children, was of a widespread nature; a veterinary surgeon—Mr. Daniel—informed me that at that time he had several patients among cats affected with the disease, consisting in an acute catarrhal affection, chiefly of the respiratory passages. He furnished me with two such animals; one that after an illness of several weeks had died, another that was sent to me in a highly emaciated state, affected with severe broncho-pneumonia; this animal was paralyzed on the hind limbs. In both instances the *post-mortem* examination showed severe lung disease, broncho-pneumonia, and large white kidneys due to fatty degeneration of the entire cortex. A similar condition is met with in the human subject in diphtheria. Further, I received from Dr. Thursfield, of Shrewsbury, the body of a cat that had died after a few days' illness from pneumonia in a house in which children were ill with diphtheria; another cat in the same house that became next ill with the same lung trouble also succumbed. The *post-mortem* examination of the animal that I received showed severe broncho-pneumonia and large white kidneys, the entire cortex being in a state of fatty degeneration.

Subcutaneous inoculations of cats were carried out with particles of fresh human diphtheritic membranes and with cultures of diphtheria bacillus (Report of Medical Officer of the Local Government Board, 1889-90); hereby a local diphtheritic tumor was produced at the seat of inoculation, and a general visceral disease; in the cases in which death followed after a few days the lungs were found much congested; when death followed after one or more weeks, the lungs showed broncho-pneumonia and the kidneys were enlarged and white, the cortex being in a state of fatty degeneration; if the disease in the animals lasted beyond five to seven days, both kidneys were found uniformly white in the cortex; if of shorter duration, the fatty degeneration was sometimes only in patches. Although in these experiments the bacillus diphtheriæ was recoverable by cultivation from the diphtheritic tumor at the seat of inoculation, there were no bacilli found in the lungs, heart's blood, or kidney, and the conclusion is justified that, just as in the human diphtheria and in the diphtheria produced by subcutaneous inoculation in the guinea pig, so also in these experimental cats the visceral disease must be a result of the action of a chemical poison produced by the diphtheria bacillus at the seat of inoculation.

From this it is seen that the similarity between the artificial disease and the natural disease in the cat is very great, and the question that presents itself is—In what manner does the animal receive or give the diphtheritic contagium in the natural disease? The natural disease in the cat is in its symptoms and pathology a lung disease, and it is reasonable to suppose from analogy that the lung is the organ in which the diphtheritic process in the cat has its seat. The microscopic examination of the diseased lung of cats that died from the natural disease bears this out, the membrane lining the bronchi in the diseased portions of the lobules presenting appearances which in microscopic character coincide with the appearances in the mucous membrane of the human fauces, pharynx, or larynx in diphtheria. But the correctness of the above supposition, that diphtheria has its seat in the lung of the cat naturally diseased, was proved by direct experiment. Broth culture of the bacillus diphtheriæ was introduced into the cavity of the normal trachea without injuring the mucous membrane. The animals became ill with acute pneumonia, and on *post-mortem*, two to seven days after, there was found extensive pneumonia and fatty degeneration of the kidney. The bronchi, infundibula, and air cells of the inflamed lobules were found occluded by, and filled with, exudation, which under the microscope bears a striking resemblance to human diphtheritic membranes, and in the muco-purulent exudation in the large bronchi and trachea the diphtheria bacilli were present in large numbers.

During the last ten or twelve years certain epidemics of diphtheria have occurred which were traced to milk, but the manner in which that milk had become contaminated with the diphtheritic virus could not be demonstrated, although the evidence as to the milk not having been directly polluted from a human diphtheria case was very strong. The epidemic of diphtheria that prevailed in the north of London in 1878, investigated by Mr. Power for the Local Government Board, then the epidemic that occurred in October, 1886, at York Town and Camberley, the epidemic in Enfield at the beginning of 1888, and in Barking toward the autumn of 1888, were epidemics of this character. Mr. Power, in his report to the Local Government Board on the York Town and Camberley outbreak, states (p. 13) that a veterinary surgeon had certified that the cows from whom the infected milk was derived were all in good health, but that two of the cows showed "chaps" on their teats, and he adds that even two or three weeks after the epidemic had come to an end—the use of milk having been in the meantime discontinued—he saw at the farm one cow which had suffered chapped teats. At Enfield a veterinary inspector had also certified that the cows were in good health; but at Barking the veterinary inspector found sores and crusts on the udder and teats of the cows.

I have made experiments at the Brown Institution on milch cows with the diphtheria bacillus, which appear to me to throw a good deal of light on the above outbreaks of diphtheria.

Two milch cows* were inoculated with a broth culture of the diphtheria bacillus derived from human diphtheria. In each case a Pravaz syringeful was injected into the subcutaneous and muscular tissues of the left shoulder. On the second and third days there was already noticed a soft but tender swelling in the muscle and the subcutaneous tissue of the left shoulder; this swelling increased from day to day, and reached its maximum about the end of the week; then it gradually became smaller but firm. The temperature of both animals was raised on the second and third day, on which days they left off feeding, but after this became apparently normal. Both animals exhibited a slight cough, beginning with the eighth to tenth day, and this gradually increased. One animal left off feeding and ruminating on the twelfth day, "fell in" considerably, and died in the night from the fourteenth to the fifteenth day; the other animal on the twenty-third to twenty-fourth day left off taking food, "fell in" very much, and was very ill; it was killed on the twenty-fifth day.

In both animals, beginning with the fifth day, there appeared on the skin of the udder, less on the teats, red raised papules, which in a day changed into vesicles, surrounded by a rim of injected skin; the contents of the vesicles was a clear lymph, the skin underneath was much indurated, and felt like a nodule; next day the contents of the vesicle had become purulent, *i. e.*, the vesicle had changed into a pustule; in another day the pustule dried into a brownish black crust, with a sore underneath; this crust became thicker and larger for a couple of days, then became loose, and soon fell off, a dry healing sore remaining underneath. The whole period of the eruption of papules, leading to vesicles, then to pustules, and then to black crusts, which, when falling off, left a dry healing sore behind, occupied from five to seven days. The eruption did not appear in one crop; new papules and vesicles came upon the udder of one cow almost daily between the fifth and eleventh day after inoculation, in the other cow between the sixth and tenth day; the total number of vesicles in the former cow amounted to about twenty-four on the udder, four on the teats; in the latter they were all on the udder, and amounted to eight in all. The size of the vesicles and postules differed; some were not more than one-eighth of an inch, others larger, up to one-half to three-fourths of an inch in diameter; they had all a rounded outline, some showed a dark center. From one of the above cows on the fifth day milk was received from a healthy teat, having previously thoroughly disinfected the outside of the teat and the milker's hand; from this milk cultivations were made, and it was found that thirty-two colonies of the diphtheria bacillus without any contamination were obtained from one cubic centimeter of the milk.

Unlike in the human, in the guinea pig and in the cat, the diphtheria bacillus passed from the seat of inoculation into the system of the cow; this was proved by the demonstration of the diphtheria bacillus in the milk. But also in the eruption on the udder, the presence of the diphtheria bacillus was demonstrated by microscopic specimens and particularly by experiment. With matter taken from the eruption—vesicles and pustules—of the udder, two calves were inoculated into the skin of the groin; here the same eruption made its appearance; red papules, rapidly becoming vesicular, then pustular, and then became covered with brown-black crusts, which two or three days after became loose and left a dry healing sore behind. More than that, the calves that showed this eruption after inoculation became affected with severe broncho-pneumonia and with fatty degeneration of the cortex of the kidney. In the two cows above mentioned, on *post-mortem* examination, both lungs were found highly congested, œdematous, some lobules almost solid with broncho-pneumonia in the upper lobes and the upper portion of the middle or lower lobe respectively; the pleural lymphatics were filled with serum and blood. Hemorrhages in the pericardium and lymph glands, and necrotic patches were present in the liver. At the seat of inoculation there were in both cases a firm tumor consisting in necrotic diphtheritic change of the muscular and subcutaneous tissue. In this diphtheritic tumor continuous masses of the diphtheria bacillus were present; their gradual growth into and destruction of the muscular fibers could be traced very clearly.

It appears then from these observations that a definite disease can be produced in the cow by the diphtheria bacillus, consisting of a diphtheritic tumor at the seat of inoculation, with copious multiplication of the diphtheria bacillus, a severe pneumonia, and necrotic change in the liver; the contagious nature of the vesicular eruption on the udder and excretion of

* Paper read before the Royal Society by Dr. E. Klein, F.R.S., on May 22. This research was undertaken for the Medical Department of the Local Government Board, and was communicated to the Royal Society with the permission of the medical officer.—*Nature.*

* The cows had been kept under observation previous to the experiment for ten days, and were in all respects perfectly normal.

the diphtheria bacillus in the milk prove that in the cow the bacillus is absorbed as such into the system.

From the diphtheritic tumor, by cultivation, pure cultures of the diphtheria bacillus were obtained; a small part removed from the tumor with the point of a platinum wire, and rubbed over the surface of nutrient gelatine or nutrient agar, yielded innumerable colonies of the diphtheria bacillus without any contamination. In cultural characters in plate, streak, and stab cultures, and in cover glass specimens of such cultures, this cow diphtheria bacillus coincided completely with the human diphtheria bacillus, but in sections through the diphtheritic tumor of the cow a remarkable difference was noticed between it and the bacillus from the cultures; inasmuch as in the tissue of the tumor the masses of the microbe, both in the necrotic parts, as also where growing into and destroying the muscular fibers, were made up of filaments, granular threads, some of which possessed terminal oval or flask-shaped swellings. But that it was really the diphtheria bacillus was proved by culture experiments and by cover glass specimens. In the latter, the transitional forms between typical diphtheria bacillus and long filaments with terminal knob-like swellings, with spherical or oblong granules interspersed here and there in the threads, could be easily ascertained. In the large number of cultivations that were made of the fresh tumor in both cows, the colonies obtained were all of one and the same kind, viz., those of the diphtheria bacillus; no contamination was present in any of the cultivations.

Appendix, May 20.—At the beginning of the month of April two cats died at the Brown Institution, after having been ill for several days, with symptoms like those of natural cat diphtheria. Between the beginning of April and the beginning of May, 14 cats became similarly affected, some more severely than others, and some died with the characteristic morbid change. This epidemic, as it may be called, commenced with the illness of the first two cats about the end of March; and the question arises as to how the disease originated in these two animals. No cats had been ill in their shed, and the two affected ones were healthy when received at the institution some weeks before. But during the latter part of March there were in the stables of the institution two milch cows ill with diphtheria induced by inoculation with the human diphtheria bacillus—in fact, the two cows already referred to. The diphtheria bacillus was found in the milk drawn from one of these animals on the fifth day after inoculation, and orders were given to the attendant that the milk of both cows was to be thrown away. This order was not obeyed, for part of the milk was given to the two cats above mentioned, and they sickened as described within a day or two afterward. It ought to be mentioned that the man in attendance on the cows had also charge of the cats, but in view of the fact that he was himself free from the disease, the possibility of his having conveyed it from the cows to the cats may be disregarded.

OBSERVATIONS OF METEORS.

The May number of the *Monthly Notices* of the Royal Astronomical Society contains a catalogue of 918 radiant points of meteors observed by Mr. Denning at Bristol since 1873, together with a mass of information pertaining to their determination. The total number of meteors seen from 1873 to 1889 was 12,083, and the paths of 9,177 of these were registered. The following table shows the horary rate of apparition of the meteors during the various months of the year:

January	6·5
February	4·9
March	6·6
April	6·6
May	5·2
June	4·9
July	11.3
August	11·8
September	10·3
October	11·8
November	11·3
December	8·9

The mean horary rate of apparition is therefore 8·3. This is less than would be observed from a place where there is no interference with the light and smoke of a large town, some observations made by Mr. Denning in a different locality increasing the mean horary number to 11·4.

The observations were almost equally distributed between the morning hours, and were usually made between the third and first quarters of the moon, because a bright sky is very effective in obliterating meteor showers, and therefore moonlight meteors are commonly rare.

As to the relative numbers which appear during the night, the maximum appears to be obtained between 2 and 3 A. M., when the rate is nearly double that observed in the early hours of the evening. Two or three meteors have frequently been noticed to appear at nearly the same time and from the same radiant, the probable explanation in such cases being that the two objects originally formed one mass, which suffered disruption owing to the vicissitudes encountered in planetary space.

The average length of path of all the meteors registered is 10·9°. The average height of either fireballs or shooting stars has been computed, from thirty-eight instances, to be:

Beginning height	71·1 miles.
End height	48·2 "

From a comparison of a large number of other similar results, the following general average has been deduced:

Beginning height	76·4 miles (683 meteors).
End height	50·8 " (736 "

If fireballs and shooting stars are separated, the usual heights of disappearance are: Fireballs, 30 miles; shooting stars, 54 miles. A considerable amount of information as to the radiant points, stationary and otherwise, has been brought together; and, with the catalogue, they render Mr. Denning's paper one of a very important character.

THE DUSSOHARA FESTIVAL IN BENGAL.

A correspondent of the London *Daily Graphic* writes as follows:

We have just been keeping the festival of *Dussohara Gunja Poojah* throughout Bengal, Behar, and Orissa, and in honor of native feelings the public offices and law courts of Calcutta were closed. To a devout Hindoo it is an important day, for the idea is that the fury of the monsoon has spent itself, and the season has arrived for the resumption of river traffic. The waters, therefore, must be propitiated with sacrifices, and these take the form of rice, cocoanuts, mangoes, or flowers. Every Hindoo who can afford it purchases at least ten sorts of fruit, some rice or a cocoanut, and a new cloth, the latter of which must be worn. I send you sketches with this, which I made upon the Hughli Pontoon Bridge, of the scene at the principal bathing ghat in Calcutta, showing the pilgrims throwing their offerings into the river. The priests made the sacrifices, and the worshipers, after performing their ablutions, turned toward their homes, making their way through enormous crowds, including the professional beggars and terrible deformities who appear on such occasions. The sacrifices, however, are not left to waste in the water, and everything not hopelessly spoiled by its wetting was fished out, generally by the priests, for their own use. Many thousands of cocoanuts and mangoes, for example, were thrown into the river, but I should doubt if five hundred were left there. At every bathing ghat were hundreds of strong swimmers, who tried to rescue everything, no matter how far it was thrown into the stream. After performing this worship of the Mother Ganges, the devotees returned home to finish the day's observances with homage to the Monosha Devi or Goddess of the Snakes. The kitchens of all good Hindoos are kept closed all day, and no rice or curry is eaten.

THE DUSSOHARA FESTIVAL IN BENGAL—THE RAMMOHUN MULLICK GHAT ON THE HUGHLI.

MANNA-YIELDING PLANTS.

By John R. Jackson, Curator of the Museum Royal Gardens, Kew.

What is generally understood by the term *manna* is a sweet exudation from the stems of the manna ash (*Fraxinus Ornus*, L.), a small tree found in Italy, and extending into Switzerland, the Southern Tyrol, Hungary, Greece, Turkey, and other places. In this country the tree is also grown for its ornamental character, but with us it grows to a height of thirty feet or more. No manna is collected from the English-grown trees. It is from Sicily that the bulk of the manna of commerce is at the present time obtained, the plants being regularly cultivated in plantations in certain localities within twenty-five miles of Palermo on the west and within fifty to seventy miles on the east. The trees, which are here planted in rows, grow to a height of from ten to twenty feet, and are about seven feet apart. A manna ash plantation is kept free from weeds, the ground is loosened, and is occasionally enriched with manure. At the age of eight years the stems have attained a diameter of about three inches, and the manna is then drawn from them, by making incisions through the bark to the wood from one inch to two inches long, and at distances from each other of about one inch.

The first cut is made at the lower part of the trunk, and the next day another is made just above it, and this is continued daily during the dry weather, after which the tree is left alone till the following season, when the untouched part of the stem is operated upon in the same way, and similar practice is continued in succeeding years till the tree is exhausted, which is usually at the age of ten or twelve years, when the stem is cut off, and another shoots up from the same stump—indeed, several stems are often to be seen growing from the same root. The very finest manna is that which has become incrusted around pieces of stick or straws placed in the incisions in the stems to receive it, but the fine quality ordinarily seen in commerce, and known as flake manna, is that which has hardened on the stem. The inferior qualities are those which flow from the lower incision, and are either collected on tiles or in the hollow of boat-shaped joints of a species of *Opuntia*. After removal from the tree the manna is laid upon shelves to dry or harden before packing. The best manna harvests are obtained in warm, dry weather, usually in the months of July and August, when the trees have fully matured their leaves.

Such then is the source and means adopted in obtaining commercial manna, the character and uses of which are well known. But several other plants yield substances somewhat analogous, which are generally known under the name of manna. Though these less known products have attracted a certain amount of attention at different times and by various writers, no careful examination, so far as we know, has been made of many of them, and it is with the view of drawing the attention of chemists more prominently to them that we have here collected together what information can be gained on the subject, in the hope that these undeveloped products may be thoroughly investigated and that some, at least, may find their way into the list of really useful substances.

Taking them in the order of the natural affinities of the plants which yield them, and not in that of their supposed importance, we find that *Tamarix gallica*, L., var. *mannifera*, a small tree or bush widely distributed in Europe, Africa, and Asia, produces in Persia and Arabia a kind of manna known by the Arabic and Persian names of "gazangabin" and "gazanjabin," names which imply Tamarisk honey. In June and July the shrubs which grow in the valleys of the peninsula of Sinai exude from their slender branches small drops of a honey-like substance, which become solid in the cool of the early morning.

The exudation is assisted by the puncture of a small insect. The Arabs collect the manna and dispose of it to the monks of St. Katharine, from whom it is obtained by pilgrims and visitors to the convent. It is also collected in Persia, but there does not seem to be any record of its collection in India at the present time, inasmuch as it now forms an article of export from Persia to Bombay. In 1861 Berthelot examined a sample of this substance obtained from Sinai, which had the appearance of a thick yellowish sirup, consisting of cane sugar, inverted sugar (levulose and glucose), dextrin, and water, the last constituting one-fifth of the whole. Dymock says that in Persian works Tamarisk manna is described as a dew which falls upon this and other trees, notably the willow and oak, and becomes solidified. The Hakims consider the manna to be detergent, aperient, and expectorant. It is sold in Bombay at half a rupee a pound, and is kept in most druggists' shops.

Astragalus.—From one or more species of this leguminous genus manna is said to be obtained in Persia under the same common name of "gazangabin." Fluckiger and Hanbury, on the authority of Haussknecht, say that this name is used at the present time in Persia to designate certain round cakes common in all the bazars, of which the chief constituent is a

manna collected in the mountain districts of Chahar-Mahal and Faraidan, and especially about the town of Khonsar, southwest of Ispahan, from *Astragalus florulentus*, Boiss. and Haussk., and *A. adscendens*, Boiss. and Haussk. The best sorts of this manna, which are termed "Gaz Alefi," or "Gaz Khonsari," are obtained in August, by shaking it from the branches, the little drops finally sticking together and forming a dirty grayish white tough mass. The commoner sort, got by scraping the stem, is still more impure. Ludwig found Haussknecht's specimen to consist of dextrin, uncrystallizable sugar, and organic acids. Dymock says that Rich, in his "Residence in Koordistan," describes the collection of Gazangabin, called by the Koords "Ghezo," by picking the leaves of the trees, getting them dry, and then gently thrashing them over a cloth, the season for collecting being about the end of June.

From these notes there would seem to be much mystery attached to the source of this kind of Persian manna, the whole question of which should be taken up and worked out by European residents in Persia.

Alhagi Maurorum, Desv.—This is a widely spread leguminous shrub, native of the plains of the Northwest Provinces of India, Upper Ganges, and Coucan. The plant is described in Sanskrit works as having laxative, diuretic, and expectorant properties; but no mention is made of its yielding manna—none, indeed, being produced in India. It is known in Arabic as "Taranjabin." It exudes naturally from the plant, and is collected by shaking the twigs over a cloth. It is collected chiefly in Khorassan, Koordistan, and Hamadan, and is imported into Bombay from Persia in skins and bags, and realizes about ten annas per lb. It occurs in whitish grains, or small agglutinated masses, in which the thorns, pods, and leaves of the plant occur. The taste is sweetish at first, becoming afterward slightly acid, and it has hardly any odor.

Mir Mohammad Husain describes *Alhagi* manna as "aperient, cholagogue, more digestible than ash manna, expectorant, a good purifer of the blood from corrupt and adust humors, when given in diet drinks, such as barley water, etc., diuretic, and with milk, fattening and aphrodisiac.

Dr. Dymock says, in Bombay fine clean white samples are obtainable during the season of import—November to January; but, unless very carefully preserved, it soon spoils in the moist climate of the western coast, running together and becoming a brown sticky mass.

A similar manna is described by some author as being produced by an allied species of *Alhagi*, namely, *A. camelorum*, Fisch., a spiny shrub of Persia, Afghanistan, and Belochistan. It is said to be collected near Kandahar and Herat at the time of the flowering of the plants, and is imported into India from Cabul and Kandahar to the extent of about 2,000 lb. annually. Dr. Aitchison says: "The country round Rui Khauf, in Persia, is celebrated for this product, whence it is exported in all directions." It is possible that there is some confusion between these two plants as manna producers, and that what has been stated under *A. maurorum* rightly applies to *A. camelorum*.

Under the name of "Shir-Khist," a kind of manna has been described by ancient writers and referred to as follows by Fluckiger and Hanbury: Haussknecht, in his paper on "Oriental manna," states that it is the exudation of *Cotoneaster nummularia*, Fisch. et Mey., a rosaceous plant, and also of *Atraphaxis spinosa*, L., a plant belonging to the natural order Polygonaceæ. It is found in the bazars of Northwestern India, being imported in small quantities from Afghanistan and Turkestan. The manna occurs in irregular roundish tears, from about a quarter to three-quarters of an inch in greatest length, of an opaque dull white, slightly clammy, and easily kneaded in the fingers. Its odor is that of manna, and its taste a pure sweet. Its solution has a crystalline fracture, and forms with water a sirupy solution, with an abundant residue of starch granules.

Shir-Khist was found by Ludwig to consist of an exudation analogous to tragacanth, but containing, at the same time, two kinds of gum, an amorphous levogyre sugar, besides starch and cellulose.

Dr. Aitchison, who has done so much to elucidate the botany of Afghanistan, in a paper read before the Pharmaceutical Society in 1886, thus speaks of this manna: "It is largely exported, and is an exudation that occurs in certain seasons and years upon *Cotoneaster nummularia*. The plant is called "Siar-chob" (black stick), and the manna "Shir-Khist," meaning hardened milk. This *Cotoneaster* is a tall, stout shrub, growing occasionally to 12 or 14 feet in height. It is met with throughout the Paropamisus range and in Khorassan, at an altitude of about 5,000 feet. Although common everywhere in these hills, it is found in greater abundance on the Siah-Koh and Safed-Koh and the Ar-dewan pass, forming regular thickets. These are also noted localities for obtaining the manna. During July, as the corn ripens, the smaller branches of the *Cotoneaster* become covered with the exudation, and this is collected by merely shaking the branches over a cloth. It is eaten largely by the people as a sweetmeat, and exported in quantity to Persia and India.

From the sandalwood or dogwood tree of Australia (*Myoporum platycarpum*, R. Br.), a saccharine substance, or manna, is exuded. It is of a dirty whitish color, with a slight pinkish tinge. It has an extremely sweet and pleasant taste, and is much sought after as an article of food by the aborigines, and is also highly appreciated by the colonists.

Briançon manna is a white saccharine substance found on the leaves of the larch (*Larix europæa*), growing on the mountains about Briançon in Dauphiny. It is most abundant in the height of the summer, and in the early part of the day. Fluckiger and Hanbury say that it was formerly collected for use in medicine, but only to a very limited extent; for in the time of Geoffroy (from 1709 to 1731) it was rare in Paris, while at the present day, though still gathered by the peasants, it has quite disappeared from trade. The manna, as usually seen, is in small whitish opaque tears, oblong and channeled, and mostly encrusting the narrow leaf of the larch. It has a slight smell and a sweet taste, and exhibits under the microscope indistinct crystals.

Many sweet, manna-like substances are known, the exudations of which are due more or less to insect agency, and are, therefore, not truly vegetable products. Among these may be included the following: Eucalyptus manna, or "lerp." This is found chiefly on the *Eucalyptus dumosa*, A. Cunn, and is the nidus of an insect. It consists of a starch-like substance of a sweet taste, and of a white or yellowish-white color. In appearance, the pieces somewhat resemble small shells. It is eaten in summer by the aborigines of the Mallee country of Victoria, where the plant is found, as also in southern New South Wales. Referring to lerp from *E. dumosa*, Mr. Maiden, in his "Useful Native Plants of Australia," gives the following extract from Fluckiger in Watts' dictionary: "This substance occurs on the leaves, and consists of white threads clotted together by a sirup proceeding from the insect (*Pyslla eucalypti*) which spins the threads. It contains in round numbers, of water 14 parts, thread like portion 33 parts, sugar 53 parts. The threads possess many of the characteristic properties of starch, from which, however, they are sharply distinguished by their form. Where lerp is washed with water, the sugar dissolves, and the threads swell but slightly, and dissolve to a slight extent, so that the solution is colored blue by iodine. The threads, freed from sugar by washing, consist of a substance called 'lerp amylum.' This is very slightly soluble in cold water, and not perceptibly more so in water at 100°, but entirely soluble to a thin transparent liquid when heated to 135° in sealed tubes, with 30 parts of water. This solution, on cooling, deposits the original substance in flocks, without forming a jelly at any time. The separation is almost complete. If the material employed in this experiment were entirely free from sugar, the liquid left after the separation of the flocks will also be free from sugar.

"The flocks deposited from solution are insoluble in boiling water; therefore, lerp amylum suffers no chemical change on being heated to 150° with water. Heated in the air bath to 190° while dry, it turns brown, and is afterward merely reddened by solution of iodine; at the same time it becomes partially soluble in hot water—hence it appears that lerp amylum undergoes a change similiar to that which occurs when starch is converted into dextrin. By oxidation with nitric acid it yields oxalic acid, but no mucic acid; it is neutral to vegetable colors, and is not precipitated by lead acetate, and is, therefore, not to be confounded with the gums," etc. We have quoted rather extensively on this subject, as lerp manna has attracted some attention of late among chemists in comparison with similar products—indeed, from the trunk of *Eucalyptus viminalis*, Lab., found in South Australia, Victoria, New South Wales, and Tasmania, a quantity of sweet saccharine juice exudes, which has a pleasant taste and is much used by the natives as food.

The tree in some localities is called the "manna gum." Mr. Maiden thus describes this manna: "It is in small pieces, about the size of peas, but of irregular, flattened shape. In appearance it very much resembles lime which has naturally crumbled or slaked by exposure to a moist atmosphere. It is composed of an unfermentable sugar called *Eucalin*, which is peculiar to the sap of the *Eucalyptus*, together with a fermentable sugar, supposed to be dextroglucose. The manna is derived from the exudation of the sap, which, 'drying in the hot, parched air of midsummer, leaves the sugary solid remains in a gradually increasing lump, which ultimately falls off, covering the ground in little irregular masses.' This exudation of the sap is said by McCoy to take place from the boring of the great black, or manna, cicada (*C. mærens*). The Hon. W. Macleay, of Sydney, is, however, by no means of that opinion, as he thinks it cannot be doubted that the manna is the work of a gall-making coccus. It is a subject that requires clearing up, and it is to be hoped that a naturalist will give his earnest attention to the matter."

On the subject of oak manna, Fluckiger and Hanbury point out that the occurrence of a saccharine substance on the oak is noticed by both Ovid and Virgil, and that it has also been mentioned by Arabian physicians and other writers of later dates. At the present day it is said to be the object of some industry among the wandering tribes of Koordistan, who collect it from *Quercus vallonea*, Kotschy, and *Q. persica*, Jaub. et Spach. In the month of August the trees are covered with enormous numbers of a small white coccus; from the punctures made by them a saccharine juice exudes which solidifies in small, grain-like lumps. These are collected before sunrise by shaking the branches of the trees on to linen cloths spread beneath them. The exudation is also collected by dipping the small branches on which it is formed into vessels of hot water, and evaporating the saccharine solution to a sirupy consistence, which in this state is used for sweetening food, or for mixing with flour to make a kind of cake. This manna would appear to vary considerably in its composition and quality, the best sort being moist and soft, and described as resembling an inferior description of ash manna, while an inferior quality is sometimes seen in hard, compact, grayish lumps, so hard as to require a hammer to break it. It is composed of sugary matter, mixed with a quantity of small fragments of green leaves. It has a sweet taste and a herb-like smell.

A very singular manna-like substance is that known as "Trehala" in Syria and as "Shukkar Tigal" in India.

These have been considered as distinct products, though closely allied. The so-called manna consists of oval-shaped cases, averaging ½ inch to ¾ inch in length, externally rough and irregular, hard and brittle, of a grayish white color and with a sweetish taste.

These cases are found attached by one side to twigs of a species of *Echinops* in Syria, and are constructed by a small beetle which has been described as *Larinus subrugosus*. The larva of this insect collects a considerable quantity of saccharine and amylaceous matter from the *Echinops*, and it constructs its dwelling by disgorging this matter and moulding it in the form to cover itself. Each case contains one insect only, and when this has attained its perfect form, emerges at the upper end. Analysis of these peculiar cocoons or nests has proved them to contain gum, starch, and sugar. Placed in water at an ordinary temperature they swell, partly dissolve, and become converted into a pasty mass. They are collected in Turkey and Syria, and used as food, and they are also exported in quantity to Constantinople and other Turkish cities.

The Shukkar Treghal, or Tigal, of India has been described as the product of a similar insect on the mudar plant (*Calotropis procera*). They are said not to be common, but in sufficient quantity for the natives to collect as an article of food. Dr. Royle describes it in his "Himalayan Botany" as a "sweetish exudation formed on the plant, in consequence of the puncture of an insect called *Gultigal*." The beetles found in a sample of the so-called manna received from India were some years ago submitted to an eminent entomologist at the British Museum, who pronounced them to be those of *Larinus ursus*, Fabricius. Further information on this interesting subject is contained in Hanbury's "Science Papers," pp. 158–163, where attention is drawn to the fact that M. Guibourt has pointed out that, under the Persian name of "Schakar tigal," these cocoons were described by Father Ange, in his "Pharmacopœia Persica," so far back as 1681; but, from that time to 1855, when they were exhibited among some drugs from Constantinople in the Paris exhibition of that year, they were practically unknown to pharmacologists.

In a note communicated by Mr. Hanbury to the Linnean Society in 1858, and published in the proceedings of that society for May, 1859, it is stated that the insect was determined by Mr. Wilson Saunders, in 1856, to be the *Larinus maculatus* of Faldermann—this determination being founded on specimens collected at Kirrind, in Persia, in September, 1851, by Mr. W. K. Loftus, whose specimens were presented to the British Museum. There is a specimen, however, in the Kew Museum, collected by the same gentleman, at the same place, and on the same date, and bearing the same name of "Shek roukeh," which is further stated to be "produced by the larva of a rhynchophorous insect on the 'Tucee' plant, which name I have been unable to trace." Two samples of gum accompany this specimen, one labeled "Gum of 'Tucee' Kourdish, from Kirrind, Persia, July, 1851," and the other labeled "Gum ('Keeje') of 'Tucee' Kourdish, near Kirrind, July, 1851." The first of these is a white gum in small pieces, not unlike gum arabic; while the second is a brownish substance, easily crumbling into small pieces, and not soluble in water. Mr. Hanbury describes a second product, collected by Mr. Loftus, near Kirrind, on July 13, 1851, as "a saccharine substance resembling dark honey," and "exuded by a species of thistle when pierced by a rhynchophorous insect." The plant was identified as *Echinops persicus*, Fisch., and the insect as a new species of *Larinus*, under the name of *L. mellificus*, Jekel. Both products would therefore appear to be formed on species of *Echinops*, but, though we have the authority of M. Guibourt that the insect cases known as "Trehala," or "Schaker tigal," are composed of a large proportion of starch of gum, a peculiar saccharine matter, and a bitter principle, as well as earthy and alkaline salts, no analysis seems ever to have been made of the dark honey-like substance. Again, the "Trehala" is stated to be abundant in the shops of the Jew drug dealers of Constantinople, and to be frequently used by the Arab and Turkish physicians in the form of a decoction, and is regarded by them as of peculiar efficacy in diseases of the respiratory organs; but to what use the second, or saccharine, substance is put has never been stated.

It is possible that Mr. Loftus' "Keeje" in the Kew Museum may be identical with the saccharine substance described by Mr. Hanbury; and it seems more than possible that the Trehala, or Schakar Tigal, of Persia, which is undoubtedly produced on a species of *Echinops*, is in every way identical with that referred to by Dr. Royle, which has been stated to be produced on *Calotropis procera*. That it has nothing to do with *Calotropis* is certain from a sample in the Kew Museum which was received from the India Museum under that name, but which contains numerous spines of unmistakable *Echinops*.

Whether any of these peculiar substances are ever likely to be useful as drugs in Europe remains yet to be proved.

Another singular product, which is a manna only in name, is that furnished by two species of *Lecanora*, namely, *L. esculenta* and *L. affinis*, lichens which are said to have appeared suddenly, or even to have fallen in the form of rain, at various times, covering vast tracts of country in Persia, Tartary, the Caucasus, the Crimea, on Mount Ararat, near Damascus, in Algeria, and in the African Sahara. The sudden appearance of these plants has been the cause of their being designated manna, as the people have believed that they have been miraculously sent in times of scarcity, and the lichens have been eaten by both men and cattle. It is thus described by Lauder Lindsay: "The manna is usually found in the form of small lumps, from the size of a pin's head to that of a pea or small nut, which are grayish or whitish, hard, irregular in form, inodorous, and insipid. Individual plants weigh from a few grains to about a couple of scruples when dry; the thallus bears no evidence of having, at any period of its growth, been attached to any base of support, and, singularly enough, analysis has failed to discover in it starch, though it has detected no less than 66 per cent. of oxalate of lime in some specimens—hence it has proved deleterious to sheep feeding on it in Algeria, and has only been used by man in extreme need." It cannot be supposed that these lichens could ever be turned to practical account, and the notice of them is only introduced here to make this list more complete. The same may be said of the following, which are described as furnishing a manna-like substance: *Pyrus glabra*, like oak manna, collected by the people in Luristan. In Persia *Scrophularia frigida* and *Salix fragilis* are said to yield saccharine exudations, and in Spain *Cistus ladaniferus*.

This list of mannas, some of which have but slight claim to the name, may perhaps be added to by those who have opportunities of observing the habits of plants, especially in hot and dry countries; for it is most likely that many other plants besides those here enumerated might be turned to some useful account in this direction.

IT appears that in Germany the probable military usefulness of a projected railroad is decided before the question of its usefulness to the people is considered. The war office must first approve before the civil government takes a step. In selecting employes, preference is given to those who have a good record as soldiers, and who are likely to be of service in utilizing the railways in case of war.

[THE CHEMIST AND DRUGGIST.]

AN ANALYTICAL LESSON.

IF you desire to analyze the bases,
Just bear in mind the following simple cases:
Mercurous salts, and silver, lead as well,
All form precipitates on adding HCl.
Then through the acid filtrate briskly pass
A stream of stinking sulphureted gas.
Of yellow sulphides you may find therein
Arsenium, cadmium, very likely tin.
Now copper, bismuth, lead,
Mercuric salts unsaid,
As sulphides all possess,
A jetty-colored dress.
That these black sulphides may not feel the duller,
Stibium cheers them with his orange color.
Now in the filtrate lurking, still unclaim'd,
May be most metals which I have not nam'd.
Of NH_4 the salts you'll need are few;
Hydroxide, chloride, and sulphydrate too
Add to your filtrate, and then wait to see
Black sulphides fall, Ni, Co, Fe.
Zinc, as a sulphide, is a snowy white:
As hydrate, Al equally is bright.
Chromium hydrate is a dullish green;
And MnS as pink alone is seen.
But here are sulphides, as you'll rightly say,
Mixed up with hydrates in a puzzling way;
But filter off, and save, with eager care,
This filtrate which contains some metals rare.
Dissolve precipitates in HCl,
With little nitric acid, and boil well;
Then add the pungent alkali, and try, mates,
To get Cr, Al, and Fe, brownish hydrates.
The filtrate found, just add the carbonate
Of NH_4, and scarcely need you wait,
When barium, calcium, strontium, down will throw
Their carbonates as colorless as snow.
Now filter off; add phosphate alkaline—
Magnesium falls if still success be thine.
Then filter off, and when the filtrate's boiled,
Lithium falls, because you'll not be foiled.
Still in the liquid, NH_4 and K
Are hiding slyly, with their friend Na.
An odor strong, on adding KHO,
Will tell of NH_4,* but this you know.
Dry the liquid by evaporating:
And salts volatilize—on waiting.
Than golden flame, no other test is surer,
To find Na; then add some aqua pura,
When $PtCl_4$ politely deigns
To tell K by sparkling yellow grains.
Although this table teaches but a part
Of the knowledge on't, it constitutes a start
For those with mem'ries good unbless'd,
And time and practice by and by'll do the rest.

JOSEPH H. VAN BIENE.

69 Loughborough Road, S. W., June 19.

ALKALI MANUFACTURE.

ACCORDING to the report on alkali, by the chief inspector, during the year 1889, for the Local Government Board for Scotland, the inspector under the Alkali Act has to determine the quality and quantity of any noxious gas found to be escaping, to ascertain if it exceeds the limits of tolerance, and the best practicable means of minimizing its emission.

The number of works which come within the purview of the act is declining. There are in England 116 alkali works, and in Scotland 16; other works scheduled in the act, 787 in England and 113 in Scotland, making a total of 1,032 registered works. This shows a decrease in the alkali works of three, and in other scheduled works of twenty, making in England alone a decrease of 23. The number of separate processes under inspection is increasing, as several distinct processes are often carried on in one establishment and by one and the same firm or company. It is interesting to find that the amount of hydrochloric acid vapor from the decomposition of salt is distinctly below one half of the statutory limit. As regards the acid gases escaping from the lead chambers, they are below one-third of the legal limit, and are still diminishing yearly.

The acids given off from chemical manure works is also decreasing. In 1883 the proportion was 0·5 grain SO_3 per cubic foot. It is now 0·349 grain, and in one district (East Lancashire and Yorkshire) reached 0·2 grain.

One firm only, manufacturers of ammonium sulphate, has been prosecuted under the act.

The salt industry has decreased upon the whole by about 12 per cent., in consequence, doubtless, of the rise in price inaugurated by the "salt ring." The production in Durham has, however, increased by 50 per cent.

The consumption of salt in the Leblanc soda process is slightly less than in 1888, viz., 584,203 tons, as against 585,498 tons. Meantime, the proportion of the salt consumed in the ammonia process is steadily increasing.

The production of ammonia sulphate is gradually increasing. Its value, taken at £12 per ton, has now risen to £1,500,000 yearly, and in the opinion of the chief inspector, this quantity might be increased tenfold.

The recovery of sulphur from the vat waste of the Leblanc process is now an established fact. The Chance process is in successful operation in twelve alkali works, although the plant required is very costly.

There is little prospect of a permanent reduction of the sale price of sulphur. Were it to be lowered, many of the Sicilian mines would doubtless be closed. The amount of tank waste deposited has now ceased to increase, but some time must elapse before the old heaps and their attending nuisance can disappear.

The influence of certain modern appliances in developing the intelligence of the workmen is fully acknowledged. As instances are mentioned the black ash revolver, the gas furnace, and the apparatus used in the recovery of sulphur by the Chance process.

Attempts are being made to suppress, or at least lessen, the injurious effects of salt works, the fumes from which, in the district of Winsford, have devastated the country for miles. Reference is here made to the value of the triple effect principle, by which, in many cases where evaporation is carried on, a vast saving of fuel and consequently of nuisance is effected. This system has been adapted to the salt manufacture by Dr. Pick, of Galicia, and is now being introduced at Shirleywich in Staffordshire.

* We allow the writer the due amount of poetical license, but he has been adding ammonia for some time. So

If NH_4 you wish to surely prove
To original salt, or sal, now move,
And to it add a little KHO,
Or soda lime, and heat it slow-
Ly. Now use your nose to smell it,
And if it's there, you'll quickly tell it.

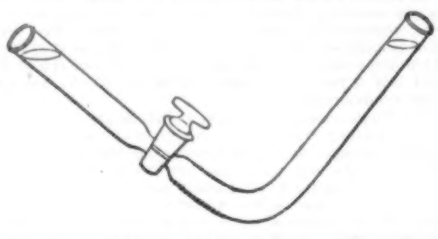
[Continued from SUPPLEMENT, No. 764, page 12210.]

ON A NEW METHOD AND DEPARTMENT OF CHEMICAL RESEARCH.*

By Dr. G. GORE, F.R.S.

B. CURVES BY VARYING THE STRENGTH OF THE SOLUTION AT ONE METAL ONLY.

THE kind of apparatus employed is shown by the annexed sketch, and is formed of glass. A weak solution, containing 1 grain of the substance in 465 grains of water was put, together with the negative metal,



platinum, into the short leg of the tube, and successive portions of solution, of regularly decreasing strength, in 465 grains of water, were put, together with the positive metal, unamalgamated zinc, into the long leg, and the electromotive force with each strength of solution was measured. The positions of the metals were then reversed, and the measurements repeated. The glass tap was closed during the process of changing each strength of liquid. In consequence of the much greater conduction resistance in the constricted portions of the solutions, the degrees of electromotive force were all much smaller than if the two metals had been near each other in the same leg. The following are the results obtained with solutions of KBr and NaCl:

Fig. 18.

Curve of KBr, by Varying Strength of Solution at One Metal only, at 16°·5 C.

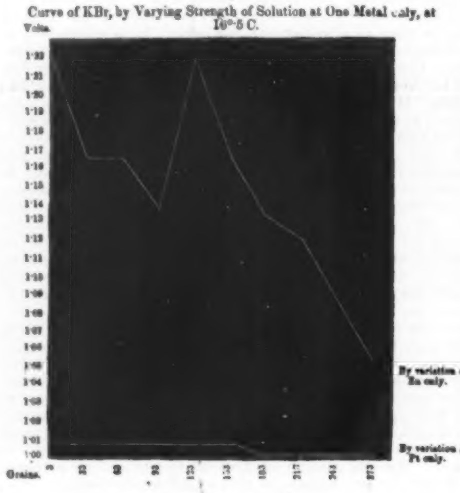


Fig. 19

Curve of NaCl, by Varying Strength of Solution at One Metal only, at 15° C

The curves show that the variation of strength of the liquid had a large effect upon the electromotive force at the surface of the zinc, but scarcely any such effect at that of the platinum; and we may conclude that when such variation of strength occurs at both metals simultaneously, the effect upon the electromotive force, and consequently also upon the form of the curves, is nearly wholly due to changes of chemical action at the surface of the zinc, and but little to such changes at the platinum.

In a third similar experiment, with a solution of 1 part of potassium chloride and 465 parts of water at 15·5° C. in the short leg, and one of the same salt, varying in strength equally in nine successive portions from 3 to 147 grains, in 465 grains of water in the long leg, the changes of strength had no perceptible influence upon the electromotive force, which remained constant at 1·1544 volts whichever metal was in the longest leg.

C. CURVES BY VARYING THE TEMPERATURE OF THE SOLUTION AT BOTH METALS.

Curve of Dilute HCl.

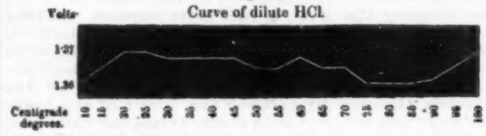
The solution contained 0·01 grain of HCl in 155 grains of water, and the electromotive force was measured every five Centigrade degrees from 10° C. to 100° C.

* From the *Philosophical Magazine* for May, 1890.

This curve shows: 1st. That the electromotive force varies with the temperature. And 2d. That a regular variation of temperature of the solution is attended by an irregular change of electromotive force. It is probable that the curve obtained by varying the temperature is characteristic of the substance, and would

Fig. 20.

Curve of dilute HCl.



be different with every substance and degree of strength of its solution.

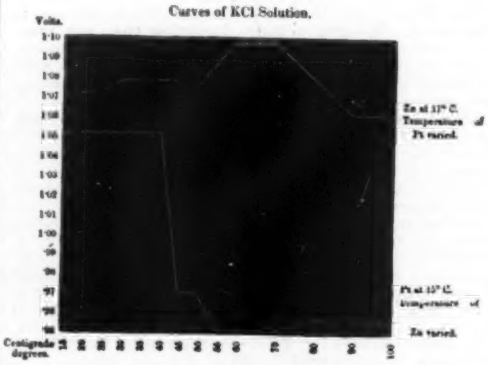
In a similar experiment with a solution of 0·027 grain of chloride of ammonium in 465 grains of water, the electromotive force of the zinc-platinum couple remained constant at 0·9084 volt at all temperatures between 14° and 100° C., and then very slightly increased.

D. CURVE BY VARYING THE TEMPERATURE OF THE SOLUTION AT ONE METAL ONLY.

In these measurements the large bent glass tube was employed (see section "B"). The liquid consisted of 39 grains of potassium chloride dissolved in 465 grains of previously boiled distilled water. In one series of measurements the zinc was immersed in the heated portion of liquid and the platinum in the cold portion; and in the other series, the reverse. The following are the curves obtained:

Fig. 21.

Curves of KCl Solution.



The two curves are very different. The greatest variation of electromotive force was at the zinc, and was = 0·103 volt, while that at the surface of the platinum was only = 0·04 volt.

The results show that the change of electromotive force which occurred on gradually heating an electrolyte and the two metals in it is a concrete effect of two influences, one of which is situated at the surface of the positive metal, and the other at that of the negative one. Each of these two influences itself would also probably be a compound effect of the separate actions of heat upon the metal and upon the liquid.

These general effects of variation of temperature described in sections "C" and "D" are very similar to those of change of strength of liquid given in sections "A" and "B."

E. GENERAL AND THEORETICAL CONSIDERATIONS.

The evidence obtained by this research shows: 1st. That every different electrolytic substance when in aqueous solution gives, by varying the degree of strength of its solution (or by varying its temperature), a different curve of electromotive force. 2d. That this curve is characteristic of the substance. 3d. That under these conditions, substances which constitute a recognized chemical group yield a series of curves which usually exhibit a gradation of likeness of form. 4th. That the degrees of electromotive force of such a group usually vary in magnitude inversely as the amounts of the atomic and molecular weights of the substances. 5th. That a much greater increase of electromotive force is usually caused by the first amount of substance added to the water than by the subsequent amounts. 6th. That the chemical union of two substances to form a soluble salt is attended by a definite decrease of electromotive force and a definite change of form of curve. 7th. That the substitution of one halogen, acid, or metallic base for another in the composition of a soluble electrolytic salt is accompanied by a definite amount of change of that force and of the form of its curve; and it will be possible to trace, by means of these changes, the presence of each halogen, acid, and metal in the various solutions of its salts. 8th. That isomeric solutions of electrolytic substances give different curves under the same conditions, and may thus be distinguished from each other. 9th. That molecular and chemical changes and their rates, in electrolytes, may be examined and measured by this method. And 10th. That if the solutions of the substances are too weak, the characteristic forms and differences of the curves are not fully developed, and if they are too strong, the measurements of electromotive force are more difficult to make. As the measurements were made at the null point when no current was passing, the curves represent the electromotive forces and molecular motions which exist under that condition; when the current passes, the molecular movements are greatly altered.

The changes of electromotive force and forms of curve obtained—1st, by the same variations of strength of the same solution at two different temperatures; 2d, by varying the temperature of a solution without changing its strength; and 3d, by varying its temperature at the positive metal only, or at the negative one only—support the general view that each substance becomes more or less a different substance at each different temperature, and that the degrees of property of each substance at different temperatures are practically infinite in number.

The results in general support the kinetic theory that

the most fundamental attribute of matter is motion, that a mass of matter is a mass of motion, that each substance consists essentially of a collection of molecular motions, and that the chief properties of bodies are consequences of such motions. Changes of volta-electromotive force are now generally recognized as being due to these motions, and as being disturbances of the universal ether which pervades all bodies and all space. Each degree of such force may also be regarded as a concrete result of an extensive series of molecular vibrations of extremely varied degrees of amplitude; this series being characteristic of the particular material combination producing it, analogous to the collection of vibrations producing a beam of light of a particular burning substance. The curves represent in addition the changes in amount of these motions; and by observing these changes in a single substance under a sufficient variety of conditions, a more or less complete graphic delineation of them as representing that particular substance might be obtained. When we are able to fully interpret the language or meaning of these curves, we shall learn a very great deal respecting the internal motions and changes of substances, and the conditions of conversion of potential into kinetic energy.

As each curve is a geometrical and quantitative representation of a series of such changes, a complete collection of such curves, yielded by all kinds of aqueous solutions, would constitute an extensive system of representations of the molecular motions of substances somewhat like that of the luminous spectra of bodies; and the magnitudes and harmonic relations of the degrees of electromotive force represented by the curves will form a very large basis of study for mathematicians, such as the spectra of bodies now afford. The entire subject appears to be nearly as large as that of spectrum analysis, and is not altogether unlike it.

The whole system of curves may be viewed as being in some respects analogous to the absorption spectra of liquids, and in a less degree to the spectra of gases. The relations between the different curves are probably more complex than those between the spectra of liquids, because the electrodes take part in the action; and still more complex than those between the spectra of gases, because of the influences of the solvent and of the electrodes, and because each dissolved substance is in the liquid state and under the influence of cohesion.

As the magnitudes and forms of the curves are manifestly related to the atomic and molecular weights of the dissolved substances, they are doubtless also related to the periodic series, and in this direction a study of them by mathematicians will lead to the acquisition of new knowledge. And as they reveal the kinetic changes which isomeric and other substances undergo when they pass from one state of chemical equilibrium to another in cases of chemical union, substitution, and decomposition, etc., they are evidently related very intimately to Newton's third law of motion.

With regard to the latter suggestion, in several researches (see "Relative Amounts of Voltaic Energy of Electrolytes," Roy. Soc. Proc., November, 1888, xlv., p. 266; "On Loss of Voltaic Energy of Electrolytes by Chemical Union," Proc. Birm. Philos. Soc., December 6, 1888, vi., p. 225; "Relative Amounts of Available Voltaic Energy of Aqueous Solutions," *ibid.*, vii., part 1; "Examples of Solution Compounds," *ibid.* and *Chemical News*, April, 1890), I have largely shown, by means of the "voltaic balance" method, that chemical union in definite proportions by weight of substances *while in aqueous solution together* is apparently universal; that elements unite with elements, with all kinds of acids, and with all classes of acid, neutral, and basic salts; that acids unite with acids, each with every other one, and each acid with every salt; and salts with each other in almost endless variey; and apparently that all kinds of dissolved chemical compounds, with but few if any exceptions, unite together more or less distinctly, in those definite proportions indiscriminately and without limit of kind, provided no separation of substance by precipitation or otherwise occurs. Also, by repeatedly doubling the molecular weight of a "solution compound" by successive additions to it of other dissolved substances of equal chemical value, each addition producing a new state of chemical equilibrium, in which chemical action and reaction are equal, I have by the same method shown that chemical union of substances while in aqueous solution together extends to large aggregates of molecules of the most varied kind and of considerable degrees of complexity (Proc. Birm. Phil. Soc., vi., p. 225). This universality of chemical union of substances while in solution together indicates the existence of an equally general cause of such union, and that cause must be a molecular one.

"The theory most consistent with these facts is a kinetic one, viz., that metals and electrolytes are throughout their masses in a state of molecular movement. That the molecules of these substances, being frictionless bodies in a frictionless medium, and their motion not being dissipated by conduction or otherwise, continue in motion until some cause arises to prevent them. That every different metal and electrolyte has a different class of motions, and that the molecular motion of each substance varies at a different rate by rise of temperature." This theory has been employed by me to explain certain thermo-electric phenomena in electrolytes (see Roy. Soc. Proc., 1883, xxxvi., pp. 54-55). "In accordance with this theory chemical action is an effect of molecular motion, and is one of the modes by which that motion is converted into electric current." "These statements are also consistent with the view that the elementary substances lose a portion of their molecular activity when they unite to form acids or salts, and that electrolytes have usually a less degree of molecular motion than the elements of which they are composed" (*ibid.*)

A kinetic theory must agree with mechanical laws; we cannot create motion or energy, all motion arises from pre-existing motion, every efficient cause of material change is a kinetic one; the immediate source of all chemical change is the latent molecular motion of the combining or mutually acting substances. As neither mere difference of substance nor union in definite proportions by weight is in itself an active influence, neither can it be the immediate kinetic cause of chemical change; but as both these circumstances invariably attend chemical union, and no such union occurs without them, we may conclude that they are necessary conditions of the union.

By adopting the above theory, "that electrolytes are throughout their masses in a state of molecular movement; that the molecules of these substances, being frictionless bodies in a frictionless medium, and their motion not being dissipated by conduction or otherwise, they continue incessantly in movement until some cause arises to prevent them," and associating it with Newton's third law of motion, viz, that "the actions of bodies upon one another are always equal and in opposite directions," we are driven to the inference that what we term "chemical affinity," or the immediate active cause of chemical union, is latent or potential molecular motion and the mutual impact and momentum of the molecules of the uniting substances. When two dissolved substances are brought by admixture of their solutions into mutual contact, a portion of the molecular motion of the one substance is neutralized by an equal amount of opposite motion of the other, and the two portions are converted into free heat, electric current, or other form of energy, and the molecules thus brought into nearer proximity retain their new positions and distances. This agrees with the usual evolution of heat, loss of voltaic energy, depression of electromotive force, and frequent increase of density, which occur during chemical union. According to this view, every dissolved chemical compound is an instance of balanced molecular motion, and it is the neutralized portions of motion which escape as heat and electric current. How far there is any originality in these ideas I leave to other persons to decide.

Many of the facts evolved by the several researches I have referred to point toward the conclusion that measurements of volta-electromotive force and voltaic energy are essentially measurements of "chemical affinity" between the dissolved substance and the positive metal. An analogous idea has already been suggested by other investigators. E. F. Herroun, adopting a view of Helmholtz's, has inferred that "the electromotive force of a voltaic cell is a measure of the actual transformation of free energy," and concluded that it "furnishes a more accurate measurement of the free energy, and therefore of true chemical affinity than data derived from calorimetric observations" (Phil. Mag., 1888, xxvii., pp. 230, 233). The amounts of voltaic energy lost by two substances during their act of chemical union clearly indicate to a large extent the quantities of opposite molecular motion neutralized by their union. For instance, a much larger amount of such motion is neutralized by the union of sodium with chlorine to form sodic chloride than by that of hydrogen with chlorine to form hydrochloric acid; and no doubt, by investigating the losses of electromotive force and voltaic energy attending the chemical union of substances in aqueous solution, we may learn a very great deal respecting the quantitative relations of "chemical affinity" between metals and electrolytes; but a great obstacle to making accurate measurements of such "affinity" by this method is the unmeasured portion of energy lost by "local action." It may be further remarked that, disregarding "local action," the chemical union and neutralization of opposite molecular motions only occurs while the circuit is closed; and that at the instant of closing the circuit, potential energy is converted into kinetic energy, and a multitude of electro-magnetic waves of very varied lengths are generated and radiated into space; the conversion of energy, therefore, in this kind of case depends upon closing of the circuit.

The results obtained by varying the strength or the temperature of the liquid at each metal separately support the conclusion that, in an ordinary voltaic cell, nearly the whole of the energy is due to action at the zinc, and but little to that at the platinum, and that the latter acts nearly wholly by obviating the greater counter electromotive force which would occur by using a more corrodible metal, and by diminishing the resistance which a less conducting substance would offer. The mere absence of an obstacle to a change cannot be an active cause of that change; and any substance which takes an essential part in any physical or chemical action, and (like the platinum plate) remains exactly the same in every respect after the action as it was immediately previous to it, cannot have been a real cause of that action, or of any loss or gain of energy attending it. The presence of the negative metal is only a static permitting condition. It enables, without any expenditure of energy on its own part, the opposite potential molecular motions of the positive metal and the liquid to neutralize each other and to be converted into voltaic current.

The method described in this paper is not merely a technical one of detecting substances, nor is it specially fitted for such a purpose; but it is an extensive new department of chemical and molecular research, and a general system of representation by means of geometrical curves, not only of individual substances, but of some of the fundamental changes of the molecular motion of substances which are inseparably related to their chief chemical properties; and it will in this way supply mathematicians with a new and extensive series of facts, representing, in terms of electromotive force, the degrees of volta-chemical action of metals and electrolytes upon each other. One of the chief uses of it as a method of research will be to examine the molecular structure and chemical composition of dissolved substances, to detect differences and changes in them caused by heat, light, chemical union, substitution, or decomposition, etc.; and to detect and measure molecular and chemical differences in isomeric liquids. It may be used to detect and measure the changes gradually produced by light and heat in chlorine water and bromine water, the influence of light upon nitric acid, the degrees of retarding effect of colored glass screens, etc., upon various chemical changes caused by light, the gradual oxidation of a solution of sulphurous anhydride by exposure to air, the spontaneous decomposition of aqua regia, the rate of decomposition of a solution of potassic iodide by chlorine water, the speed of displacement of one acid by another, etc., etc. The examples given and researches suggested are sufficient to indicate the very great extent of the subject.

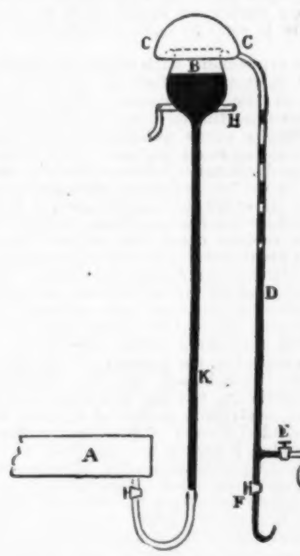
A MERCURY STILL FOR THE RAPID DISTILLATION OF MERCURY IN A VACUUM.

By FREDERICK J. SMITH, M.A., Millard Lecturer in Mechanics and Physics, Trinity College, Oxford.

WHEN mercury is distilled in a vacuum, in the usual apparatus, a large portion of it when vaporized, on reaching the internal domed surface of the bulb in which the operation is conducted, forms itself into minute spheres, which grow heavy and run down the inside of the bulb; and only a small quantity of the metal finds its way into the central tube, from which it is caught for use.

The advantage of the new form of vacuum mercury still, of which I venture to give an account, is that all the mercury which condenses in the head of the bulb is prevented by its shape from returning to the mercury from which it has been separated by heat. This is not the case in the mercury still of Weinhold, or Clark, or in those stills in which only the mercury which collects in the eduction tube is caught, as in the beautiful new form of apparatus devised by Messrs. Dunstan & Dymond, for the purification of small quantities of mercury (*supra*, p. 367). In the former of these instruments, some portion of the mercury vapor condenses on the surface of the bulb and then falls back to the mass of mercury from which it has just been separated. The mercury still which is described in the following lines has been constructed with a view to obtain a more rapid yield of pure mercury than stills of this class have hitherto been capable of producing. The yield of mercury from the new form of still is about four times as great as that from one of the old pattern, the consumption of gas in each case being the same. The construction and method of using the still are as follows: BK is a bulb and tube about 34 inches long, supported on a stand not shown; the bulb has a ring-shaped channel, CC, round its upper end; into this channel a piece of "Sprengel" tube, D, is fused. This is furnished with two taps of glass, E and F; E is in connection with a water jet pump, F is terminated with a piece of bent tube. A is a cistern for holding the mercury which is to be distilled. H is a ring of gas jets.

The method of using the still is as follows: The tap, E, is opened, F is closed; a water pump then exhausts the whole system, and the mercury to be acted on rises from the cistern, A. The cistern being large and shallow, only a slight change takes place in the height of



the mercury in the bulb, when the level of the mercury in the cistern changes. While the pump is exhausting, the ring of gas jets is lit, and in about ten minutes, in the case of the still in our laboratory, the mercury fills the tube, D, any metal which comes over being caught in the bulb, G. The tap, E, is then closed and F opened; the still then continues to work by virtue of the vacuum formed by its own mercury. It has been found necessary to place a gas regulator on the pipe which supplies the jets, as the change of pressure in the gas mains is considerable. An automatic arrangement, depending for its action upon the height of the mercury in the cistern, shuts off the gas when the surface of the mercury falls below a certain point. In using stills of this class the mercury before distillation should be carefully freed from moisture, as a minute quantity of water will often cause a fracture in the heated tube or bulb.—*Philosophical Magazine.*

THE PHOSPHORESCENCE PRODUCED UPON THE FIRST CONTACT OF OZONE WITH CERTAIN FLUIDS.

By ERNST FAHRIG.

SOME years since, in experimenting with some new liquid preparations of ozone, I accidentally observed a phenomenon which immediately attracted my attention, and led me to make many more experiments upon the subject. But these further tests, instead of clearing up the matter by affording a definite explanation of the peculiar action produced, only mystified me the more; for they merely served to upset the various theories and explanations which have from time to time suggested themselves, not only to me, but to scientific friends to whom I have mentioned the matter; and in my own view, they render no less untenable a theory which has been publicly advanced by some others who have independently discovered and worked in the same field, and to which I shall presently refer. Thus perplexed, I have resolved, with the editor's kind permission, to publish an account of these experiments in this journal, in the hope that some among its wide circle of readers may be able to throw some fresh light upon the question.

My first observation of the phenomena was in the following manner: I was in a dark room, and having in my hand a sealed bottle about three-quarters full of a preparation of ozone (in this instance a solution of ozone in water containing a small percentage of other substances, which I have found in the course of my experience are necessary to retain the ozone in solution), I with no particular purpose in view gave the bottle a vigorous shaking up; instantly I

saw a soft phosphorescent glow of light floating above the surface of the liquid and permeating the space in the upper part of the bottle. Its appearance was only momentary; but on shaking the liquid up again immediately afterward it was observed again, but in much diminished intensity. Further repetition failed to produce any results, but after an interval of ten days the liquid had apparently regenerated its power, and the same effects could be observed, though weaker. I observed the phenomena in another way, and obtained some especially remarkable results by pouring a small quantity of an ozone solution into a glass beaker containing ordinary water. At first the cone-like projection of the solution where it falls into the water becomes luminous, and then the light suffuses the whole mass as the liquids become thoroughly mingled, and finally disappears. Similar experiments to this have since been successfully carried out by the gentlemen above mentioned as having worked in this direction; and it is doubtless upon consideration of this particular variation of the phenomena that they have based their theory.

Now it does not seem possible that the luminosity can be due to a purely chemical action among the various inorganic constituents brought together, for a careful consideration of the properties and chemical reactions of these does not indicate the likelihood of any such action taking place. I have found, indeed, that it is essentially dependent upon some peculiar property of the ozone, and that it is in no wise influenced by the medium, solvent, or condition in which this is presented to the water. That is to say, the appearance of the phosphorescence is not thereby interfered with in entirety, although there is some difference of degree in the intensity produced. Thus, with preparations of ozonized oil the same effects occur, and also with ozonized air or the pure gas itself. The latter is applied by means of a glass tube immersed in the water, and with this method there is a marked increase in the duration and intensity of the phosphorescence. Or an easy way, very similar to my first experiments, of observing the effect is to take a bottle partly full of ordinary water and confine ozone gas or ozonized air in the remaining space. When shaken up in the dark, the upper part of the bottle is seen to become permeated with the light.

Trying the experiment with other substances in place of ozone, I each time failed to produce the least appearance of the phenomena. Thus, chlorine, an element which in the striking similarity of its reactions to those of ozone exhibits a remarkable analogy to that gas—so much so, that it is extremely difficult to test or distinguish between the two—absolutely would not afford the slightest glimmer of light; although it, of all other substances, should be the most likely to produce analogous effects to those of ozone. To be quite certain upon this point, I applied the chlorine in a great many different ways and conditions, but always with the same negative results. Thus, free chlorine gas, chlorine water, chlorinated soda hypochlorides, chloride of lime, and ordinary bleaching liquors were all subjected to experiment, and in every case, as with numerous other substances, peroxide of hydrogen included, the already strongly established conclusion was confirmed, that the phenomenon is wholly and solely due to some remarkable action of the ozone, and to electrically produced ozone alone.

Having satisfied myself of this in a sufficiently exhaustive manner, I turned my attention to water into which the ozone preparations are introduced, and endeavored to determine how variations in its quality and source might influence the effects. In this direction I met with a series of most strangely conflicting results. I found that some samples of water would duly give off the momentary glow of light, upon the application of the ozone, while others would not; but the most curious fact was that examination or analysis failed to discover any cause to which these and negative results might be assigned, or any explanation by which they might be reconciled. In river water the light was very good; in some from a deep well there was none whatever. In sea water there was none, and altogether there is a great and inexplicable uncertainty about the probable behavior of any particular specimen of water, which makes it practically impossible to foretell the result when first trying the experiments with a new sample, although the characteristic impurities and conditions of the same may be well known and understood beforehand. It was owing to this same uncertainty that I was much vexed a short time since by failure in an attempt to exhibit the phenomena to a party of scientific gentlemen; while on the very next day I was able to succeed with almost identical materials and conditions. Hence, also, the great difficulty of arriving at any plausible explanation.

The theory before referred to, and which is apparently the most probable of any that has yet been suggested, is that the light is generated during the destruction or oxidation of the organic matter of the water, or in killing the bacteria or micro-organisms which it may contain. But I think this cannot be sustained in view of the tests made with different samples of water; for it is evident that were this the case, the appearance and intensity of the effects would depend upon the presence and proportional amount of organic matter in the water, which, however, does not seem to be at all agreeable with experience. In fact, I have found that water previously boiled and filtered, to free it from bacteria and other organic life, does not thereby become indifferent to the experiment, thus furnishing what would seem to be a very strong and direct negative to the aforesaid theory. But in justice to its exponents, I should add that they deny it is possible to destroy bacteria by boiling, in which statement I understand they are supported by the great bacteriologist Dr. Koch, and they further affirm that this important office can only be effectually performed by means of ozone. If they are right in this contention their theory must be allowed to stand; but to prove it thoroughly it will be necessary to show a closer connection between the intensity of the phosphorescence and the observed proportions of micro-organic life than can at present be said to exist.

As to the light itself, I can only describe it as a soft phosphorescent glow, which quickly spreads through the mass of fluid or gas, as the case may be, and as quickly disappears. It is very similar in appearance to that of another phenomenon which I believe I was the first to observe some ten or twelve years ago, and of which also I have been unable to find any satisfactory explanation. It is that when the globe or bulb of an old incandescent lamp is lightly rubbed with the hand and then immersed in water, slightly warm, or simply breathed upon, a distinct light is observed to be diffused through the globe—in the dark, of course. I have laid especial emphasis upon the fact that the lamp must be an old one, because herein lies the peculiar interest of the experiment. For at first sight one naturally supposes that the same results can be obtained with an ordinary piece of glass; but this is not so; neither can any response to the experiment be excited in a new or unworked lamp. Of this I fully assured myself by making lamps specially for the purpose and subjecting them to tests to see if it was not some hitherto unobserved property of an exhausted bulb of glass. Therefore, as the vacuum, pure and simple, is not the cause, it would seem that the light is in some way dependent upon some sort of chemical change in the minute quantities of gases remaining in the bulb, produced by long contact with the incandescent filament. Gaseous compounds may be thus formed, which under the condition of extreme rarefaction may have the property of phosphorescence when subjected to electric strain. Still this does not leave the reason for moistening the bulb at all clearly defined; though the function of this process is doubtless to accomplish a rapid discharge of the electricity generated by the friction of rubbing.

In conclusion I may throw out a suggestion that the luminosity in the first case is due to a release of the energy stored up in the ozone at its creation, but I will say nothing as to its plausibility, or as to how it appears to meet the case.—*Chem. News.*

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